O55 Process and Structural Health Monitoring of a Composite Overwrapped Pressure Vessel

H. Rocha[1,2]*, P. Antunes[2], U. Lafont[3], J. P. Nunes[1]

[1] *Institute for Polymers and Composites – University of Minho*
[2] *PIEP – Innovation in Polymer Engineering*
[3] *European Space Agency*

*helenarocha@dep.uminho.pt

Keywords : Composite Overwrapped Pressure Vessel; Fibre Bragg Grating Sensors; Barely Visible Impact Damage, Structural Health Monitoring; Fatigue Pressure Cycling; Process Monitoring

Abstract

Replacements for fossil fuels in the transportation industry are being explored, to restrain global warming. Hydrogen-powered fuel cell systems, with Composite Overwrapped Pressure Vessels (COPVs) for hydrogen storage, are regarded as a viable alternative energy solution. COPVs, which consist of a fibre reinforced polymer composite overwrap wound around a liner, are the most weight efficient pressure vessel solution.

COPVs may face some reliability issues due to loading scheme complexity and material degradation. Sensor embedment into COPVs, for the application of Structural Health Monitoring (SHM) systems with continuous data acquisition, provides added safety enabled by real-time detection of critical defects.

In this work, optical fibre Bragg grating (FBG) sensors were embedded into a 1-litre type III COPV to be used in an unmanned aerial vehicle. A single optical fibre having eight FBG sensors was placed around an aluminium liner to form a grid network. Having the FBG sensors firstly fixed to the liner, allowed to monitor the following manufacturing steps: prepreg tape winding by a 6-axis winding machine and curing in an atmospheric oven. Compressive strains were observed as the carbon fibre/epoxy prepreg tape covered the FBG sensors during winding of circumferential layers, whereas the strain values remained approximately constant during the deposition of the helical layers. The FBG sensors also detected polymerization during the curing procedure. After production, the FBG sensors were able to locate barely visible impact damage (BVID) inflicted on the external surface of the COPV. The residual strain amplitudes measured by different pairs of FBG sensors allowed to locate the impacts with an error of up to 56 mm between the predicted and real impact location. Moreover, the ability of the FBG sensors to monitor the operating life of the COPV was demonstrated by pressure cycling testing, to mimic hydrogen charging and discharging cycles. Figure 1 shows the strain measured by a 4-FBG sensing array at the highest pressure amplitude tested (3 – 500 bar). As expected, according to structural finite element analysis performed, FBG1, the sensor closer to the dome section, presents the lowest strain amplitude. The FBG sensors showed a linear response to the applied pressure.

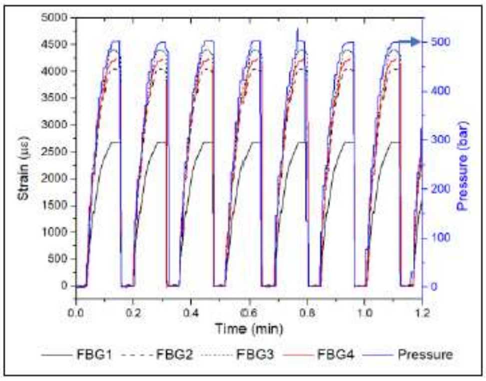

Figure 1. Strain measured by the FBG sensors during pressure cycling test between 3 – 500 bar