

Structural health monitoring of composite wound pressure vessels

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Abstract

The increasing use of advanced composite materials in the wide range of applications including Space Structures is a great impetus to the development of smart materials. Incorporating these FBG sensors for monitoring the integrity of structures during their life cycle will provide valuable information about viability of the usage of such material. The use of these sensors by surface bonding or embedding in this composite will measure internal strain and temperature, and hence the integrity of the assembled engineering structures. This paper focuses on such a structure, called a composite wound pressure vessel. This vessel was fabricated from the composite material: TRH50 (a Mitsubishi carbon fiber with a 710-ksi tensile strength and a 37 Msi modulus) impregnated with an epoxy resin from NEWPORT composites (WDE-3D-1). This epoxy resin in water dispersed system without any solvents and it cures in the 240-310 degrees F range. This is a toughened resin system specifically designed for pressure applications. These materials are a natural fit for fiber sensors since the polyimide outer buffer coating of fiber can be integrated into the polymer matrix of the composite material with negligible residual stress. The tank was wound with two helical patterns and 4 hoop wraps. The order of winding is: two hoops, two helical and two hoops. The wall thickness of the composite should be about 80 mil or less. The tank should burst near 3,000 psi or less. We can measure the actual wall thickness by ultrasonic or we can burst the tank and measure the pieces. Figure 1 shows a cylinder fabricated out of carbon-epoxy composite material. The strain in different

directions is measured with a surface bonded fiber Bragg gratings and with embedded fiber Bragg gratings as the cylinder is pressurized to burst pressures. Figure 2 shows the strain as a function of pressure of carbon-epoxy cylinder as it is pressurized with water. Strain is measured in different directions by multiple gratings oriented in both axial and hoops directions.

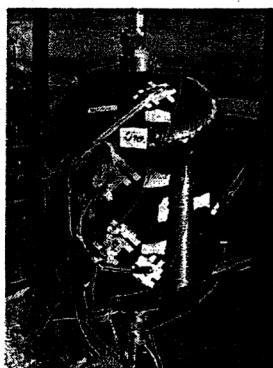


Figure 1a. FBG strain function as vessel is pressurized by water

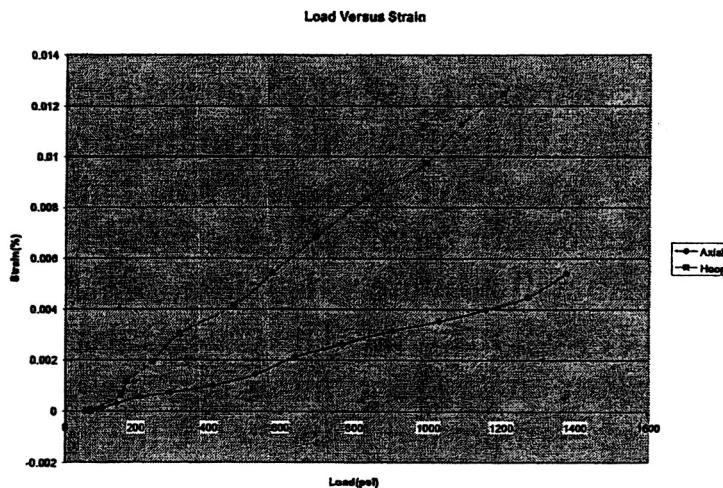


Figure 2a. FBG strain function as vessel is pressurized by water

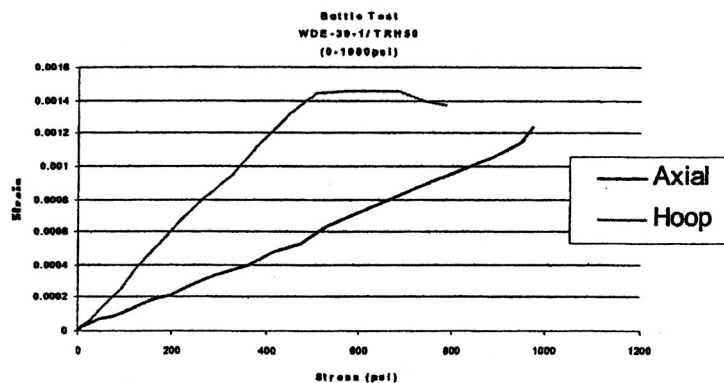


Figure 2b. FBG strain function as vessel is pressurized by water