ABSTRACT

The widespread applications of fiber reinforced polymer (FRP) composites are restricted because of the concerns related to their instability in quality and accurate assessment of long-term performance in hostile environments. To address these, in this thesis smart FRP composites are manufactured by embedding fiber Bragg grating (FBG) strain and temperature sensors using hand lay-up (HLU) and vacuum assisted resin infusion molding (VARIM) techniques. During manufacturing, strain and temperature signals obtained from the embedded sensors are processed and correlated with key stages of curing. To validate these stages of curing and to estimate the cure initiation and completion time, conventional techniques such as differential scanning calorimetry (DSC), thermal mechanical analyzer (TMA) etc. The time when strain starts to progress and attains a constant value coincides with the onset and completion of the curing respectively. However, in FRP composites with thickness>5 mm, the cure initiation and completion times at different layers are not same. This is assessed by processing the strain and temperature at different layers in a 14 mm thick FRP composite. Moreover, the defects developed during manufacturing are assessed and located by embedding multiple strain sensors in FRP composites. The long-term performance of smart FRP composites are further evaluated by exposing them to corrosive produced water and UV radiation for 270 days and 42 days respectively. The strain developed within the FRP composite and the mechanical property deterioration are measured with time. The strain is further mapped with percentage of property retention to establish a strain-based health monitoring technique. After 270 days of corrosive immersion, nearly 35 % reduction in flexural strength is observed which corresponds to a strain of 160 $\mu\varepsilon$. Similarly, after 42 days of UV aging, 10 % reduction in flexural strength is observed which corresponds to a strain of 130 $\mu\varepsilon$. Also, the performance of existing GFRP structures and thickness of solid wax deposition are estimated by mounting the sensors over the composite structures. This work shows that the smart FRP composites with embedded and surface-mounted sensors act as a promising material which ensures accurate and timely assessment of the performance of FRP composite structures.

***Key Words*:** Smart FRP composites; FBG sensors; cure; residual stress; delamination; corrosive medium; UV irradiation.