161 Investigation of Surface Strain Fields of Thermoplastic Composites Using Fibre Optic Sensors

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Extended abstract. During the last decades, fibre-reinforced composite materials have been extensively used in the design of advanced engineering structures in lieu of conventional materials (e.g. metallic alloys) due to their inherent advantages, such as high specific stiffness and strength, long fatigue life and superior corrosion resistance. However, the complex nature and the complicated degradation and failure mechanisms of composite materials tend to limit their use within primary structural parts, underlining the vital need of structural health or condition monitoring for composite structures in order to accomplish a more widespread utilization. Thus, in the recent years, structural health monitoring (SHM) concept has been evolved and considered as an excellent method to monitor the through-life health state of structures, as well as to predict their life span. One of the most widely used SHM techniques for structural integrity assessments is the fibre optic sensor (FOS) technology. The latter presents several favourable characteristics, such as immunity to electromagnetic fields, multiplexing capability, linear response, embedding applicability into structures, etc.

Fibre Bragg grating (FBG) based FOS technology has shown excellent results for strain monitoring in advanced composite structures. In this technology, the strain fields of the host structure are calculated with the use of the strain sensitivity coefficient (F_g), which is primarily related to the type of the optical fibre core and the gratings. However, the mechanical strain transfer from the host material to the FBG sensor is also influenced by the geometric and mechanical characteristics of the adhesive layer. Nevertheless, in the majority of previous research the strain calculations are based on “typical values” of F_g, generally provided by the manufacturer; these values usually do not consider sensor’s additional protective material (e.g. polyamide coating) effects, as well as the geometric and material parameters of the adhesive layer [1].

In the current work, aiming to investigate the aforementioned parameters, FBG strain sensors have been mounted on a carbon fabric reinforced polyphenylene sulphide (PPS) specimen with two different adhesives, namely a cyanoacrylate and a two-component epoxy-resin. The flat composite sample was subjected to tensile static loads, while for the assessment of the FBG readings benchmark measurements were carried out with the aid of electrical resistance strain gauges, extensometers and non-contact camera systems using digital image correlation (DIC) technique. The strain sensitivity analysis revealed that the thickness of the adhesive layer plays a crucial role in the strain transfer mechanism from the host material to the fibre optic sensor. For the cases where the adhesive thickness is quite high (e.g. more than twice the diameter of the optical sensor), major discrepancies were observed compared to benchmark results. On the other hand, when minimum thickness of adhesive layer is achieved, the results showed that the FOS calculated strain fields on the specimen’s surface are consistent with those extracted using the DIC, extensometer and strain gauge readings. Thus, due consideration should be given to ensure minimal thickness of adhesive layer during FOS installation.

References

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