Project description for MSc thesis proposal

Computational analysis of embedded tilted FBG sensor in composite material

The high specific strength and stiffness of thermoset composite materials has allowed them to slowly supplant traditional materials in numerous technological fields such as aerospace and aeronautics, automotive, naval, wind turbines, and railways. The composite manufacturing process is a crucial step to obtain the best mechanical performance from the structure, especially with increasing of the material thickness. Then, the investigation of the material state during the composite curing becomes the key to avoid possible defects which would induce premature failure of the structure.

For this purpose, the same concepts of Structural Health Monitoring (SHM), for a composite structure, can be considered extended also in the case of manufacturing processes. In the last decades, Fibre Bragg Grating (FBG) sensor was considered one of the best promises for embedded real-time monitoring of composite structures, as it proved capable of meeting the embedding and monitoring requirements. Nowadays, a new kind of Bragg grating sensor, called weakly Tilted FBG (TFBG), is studying for the same aim as its special super-imposed Bragg grating structure bestows further measuring abilities to the sensor maintaining the embedding benefits of FBG. However, due to transverse loads, the embedding of the FBG sensor could result in a geometrical change of its shape and induce strain/stress state that cause birefringence effects in the optical dielectric material of the waveguide and, consequently, a variation in the FBG spectrum. Recent researches shown that, generally, the birefringence causes the splitting of the reflected/transmitted peak in the FBG spectrum into two or more peaks. Nevertheless, although the reflected spectrum of TFBG is similar to that of the FBG sensor, the TFBG transmitted spectrum is more complex and composed by numerous peaks which are fundamental for the sensing scopes. In literature, the effect of birefringence due to transverse loads on the transmission spectrum of TFBG sensor has not yet been sufficiently addressed.

Based on the descriptions above, here are proposed list of tasks in this master's thesis project:

1. Literature review. In this phase the objectives are to acquire knowledge about the TFBG sensor, its sensing abilities and embedding methodologies into composite materials. The candidate is also requested to investigate further about the effect of transverse loads on FBG/TFBG sensors and embedding fibre optic sensors in composites. This phase should include a preliminary estimate on the transversal strain distributions on the cross-section and along the length of the optical fibre.
2. Modelling an optical fibre model on a FEA commercial software (Abaqus, Comsol, Ansys,…) to obtain the profiles of load on waveguides induced by several loading tools (ball, pin,…).
3. We wish create a model that considers the embedded FBG sensor in the composite material during the curing step.
4. The models simulated to the second point will be experimentally performed to obtain the TFBG spectra, which will be compared with the spectra obtained numerically.
5. Writing thesis and journal/conference paper.

Estimated time: 9 months.

Supervisors:

Dr. Roger M. Groves

Eng. Luigi Fazzi