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Corresponding author: AIMASSO Alessandro
e-mail of corresponding author: alessandro.aimasso@polito.it
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Title
Thermomechanical calibration of FBG sensors for aerospace applications

Authors
Alessandro AIMASSO [1], Matteo Davide Lorenzo Dalla Vedova [2], Paolo Maggiore [3]*

** Corresponding author*
[1] Dept. of Mechanical and Aerospace Engineering, Politecnico di Torino, Turin, Italy, alessandro.aimasso@polito.it
[2] Dept. of Mechanical and Aerospace Engineering, Politecnico di Torino, Turin, Italy, matteo.dallavedova@polito.it
[3] Dept. of Mechanical and Aerospace Engineering, Politecnico di Torino, Turin, Italy, paolo.maggiore@polito.it

Abstract
Optical fibers have found widespread use in a multitude of areas over the last few decades. Their main application field is communication, but they are gaining interest and their implementation is spreading even in the medical sector, as well as the infrastructures and engineering. Other than being utilised for signal transmission, optical fibers can also be used to house specific types of sensors, such as *Fiber Bragg Grating* (FBG) sensors. This type of sensor is capable of reflecting a wavelength, known as the Bragg wavelength, which can be influenced by the physical deformations of the sensor itself induced by variations in ambient conditions. Thus, FBGs are allowed to be used for the measurement of deformations, vibrations, temperature and humidity variations. These characteristics, combined with the fiber's properties in terms of small size and weight, immunity to electromagnetic interference and possibility of being easily integrated into composite structures, make them excellent candidates for sensing elements in aerospace applications.
The main subject of this work is an investigation of the behaviour of FBGs glued on composite material structures as temperature and mechanical strain sensors. At first, the activity discussed starts with an experimental calibration of FBG for temperature and strain measures, thanks to the development of a specific test bench—including a climatic chamber, sensors of temperature and strain, mechanical supports, control software, etc. However, a significant problem of FBG is represented by cross-sensitivity, which means that if thermal and mechanical loads act on the sensor at the same time, it is not possible to make an a-priori decoupling of the two contributes. So, in order to isolate the thermal effects from the mechanical ones, alternative approaches in this regard are proposed and experimentally tested. The issue of thermal decoupling is addressed, at first, by using a hybrid system of digital and optical sensors, then with an intermediate solution composed of two optical-only systems, mechanically decoupled from each other. Finally, a proposal for an innovative and completely autonomous optical configuration is analysed.
The results achieved have enabled the validation of a thermomechanical decoupling methodology that can guarantee a concrete implementation possibility of FBG sensors on composite material structures. The presented solutions succeeded in decoupling thermal and mechanical phenomena, either through the use of a mix of optical and digital sensors, or through exclusively optical sensors. The variety of the proposed approaches guarantees a high degree of flexibility and the possibility of selecting the sensor configuration that best suits the needs, depending on the type of application. In particular, an optical-digital system is the easiest approach to implement while assuring excellent results in terms of decoupling. Similarly, it has been verified that a system composed exclusively of optical sensors mounted on two mechanically-decoupled structures, one of which is not subject to mechanical deformation, can also lead to excellent results. For really complex systems, the final goal is to develop a strategy in order to achieve the results with

a completely optical sensor network installed on a single structure. However, in this case, more tests should be conducted to reach enough accurate results.

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