SMARTFIBER: Enabling cost-effective, miniaturized structural health-monitoring of composite structures

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Composites structures are setting in a new era in civil engineering! Properties like reduced weight, increased strength, and chemical resistance, create possible applications that could not be achieved using traditional construction materials such as steel or concrete.

However, due to their anisotropic properties, composites demonstrate some peculiar damage mechanics, which are difficult to detect using traditional inspection techniques. In order to reduce current, excessive safety factors and enable maintenance decisions based on actual data rather than arbitrary guidelines, a more advanced method of health-monitoring should be employed.

While methods such as ultrasonic scanning and acoustic emission are able to accurately detect damage, they all require extensive facilities and the structure needs to be taken offline. This inevitably results in high maintenance costs due to the down-time of these structures. A promising alternative is the use of optical fiber sensing technology. This technology can enable fully embedded (even multi-axial) strain sensing without taking the structure offline. The use of light as a measurand, makes the sensor resistant to radiation and EM-fields, giving it the upper hand over electrical strain gauges.

However, connecting such an optical fibre sensor to its read-out unit still requires a (fragile) exit point out of the composite, which is a downside when automated procedures are envisioned. Additionally, the read-out equipment is often very costly and power-consuming.

SMARTFIBER will attempt to overcome these issues by miniaturisation of the read-out unit and light source. The miniaturized system will be sufficiently small so that it can be embedded inside the composite structure, removing the fragile exit point. Additionally, the project will pay strong attention to the automated embedding of the entire system. In order to create a truly versatile and embedded system, power supply and data output will be achieved wirelessly.

UGent will play a prominent role in modelling all interactions between the optical fiber, read-out unit and surrounding host composite material. Additionally, UGent will determine the optimal shape and strength of the read-out unit, as well as provide the best coating parameters of the optical fiber to maximize sensor resolution. These design criteria will be selected in order to minimize distortion and strength reduction of the host structure. Research will be performed experimentally and supported by finite element simulations.

This system could have numerous potential applications. It could, for example, be embedded in a wind turbine blade for continuous monitoring. The wireless capabilities resolve the problem of the rotating blades, while the miniaturized system reduces the impact on strength of the heavily-loaded structure. Since it can be fully embedded, the aerodynamic shape of the structure remains unaffected. Continuous monitoring of such a turbine blade could enable the operator to increase the total efficiency of the turbine. Additionally, the total life-span can potentially be increased, reducing the cost-of-ownership.

SMARTFIBER clearly has the potential to increase the use of structural health-monitoring and thereby reduce cost-of-ownership, maintenance time and increase security.

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