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AN INTRODUCTION TO FIBER OPTIC SENSING FOR COMPOSITE MATERIALS

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An Introduction to Fiber Optic Sensing for Composite Materials

by

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ABSTRACT

In the last decade, the focus of application for advanced composite materials has slowly turned from aerospace to marine, civil, construction, and transportation industries. The properties of composite materials which make them attractive for such applications include their high strength to weigh ratio and resistance to corrosion. Composites have recently been used in civil engineering applications including rehabilitation projectors, prestressing tendons, reinforcing bars, and most recently as innovative structural members of bridges. As well, they have found many applications in the quest to reduce the top side weight of marine vessels. Composite sandwich panel hulls are also becoming more common.

The use of composite materials on such applications has been slowed somewhat due to the fact that they are the "new kid on the block," and because there is a lack of reliable long term field data, as compared to the traditional structural materials such as steel. Designers also need larger and more standardized databases of material properties for the multitude of existing composite materials.

For these reasons, composite materials lend themselves as prime candidates for another rapidly expanding field of research known as "smart materials." A smart material is a structure which contains a built in sensing device that can be used to continuously monitor the current state and serviceability of the structure. This is referred to as a "passive" smart material which has many applications in both marine and civil structures. More sophisticated smart structures have embedded sensors to monitor performance; the ability to compare the measured data to specification; and the means to apply corrective forces through embedded actuators. These structures are called "active" smart materials (intelligent materials) and have the most potential for application in high precision engineering structures. Composites are also good candidates as smart materials because their "build up" fabrication techniques inherently allow for the embeddement of sensors and communication lines.

The internal sensing of a smart composite material is achieved with optical fibers which function as both a sensing element and data transmitter. There are a variety of fiber optic sensors which can measure such external forces as pressure, temperature, strain, and vibration. Two types of fiber optic sensors which appear to have the most promising commercial benefit include the Fabry Perot extrinsic sensor, and the Bragg Grating sensor. A key advantage with embedded optical fibers and sensors is that their small size does not greatly effect the mechanical properties of the composite material.

The benefits of optical fiber sensing techniques as compared to the traditional foil gauges include: low weight, corrosion resistance, resistance to electromagnetic interference, reduced cabling, and excellent sensitivity.

Key issues which need to be addressed to allow for the successful production of smart composite materials include:

- embeddement of optical fibers, sensors, and connectors within a composite material;
- removal and protection of optical fiber leads from within a composite;
- survivability of optical fibers during processing of composite materials;
- effects of optical fibers, sensors, and connectors on the strength of composite materials; and
- adaptation of the above issues from hand layup fabrication to more automated processes such as pultrusion, filament winding, or tape laying.

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