Measurement of process-induced strains by embedded fiber-optic strain sensors in composite materials

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ABSTRACT

Observation and strain control in various objects are very important task in preventing accidents. Traditionally, most structures are observed according to special maintenance schedules using visual inspection methods and conventional sensors for monitoring damage. Significant disadvantages of these methods of structural monitoring are the high cost of maintenance, lack of accuracy in visual inspection and the sensitivity of sensors to harsh environmental conditions.

Among various sensors for measuring mechanical damage in objects made of polymer fibrous and granular composite materials (concretes), fiber-optic strain sensors (FOSS) have a special place. Over the past few years, FOSS based on Bragg grating has proven to be a suitable, accurate, and cost-effective tool in such structures as high-rise buildings, bridges [1], tunnels, dams, wind generators [2], geotechnical objects [3]. For existing structures, FOSS can be attached to the surface of the structure, whereas for new objects they can be embedded in the structure during the manufacturing process without any serious impact on the integrity of the structure. Information obtained with the help of FOSS in real time can provide an early warning about the violation of the integrity of structures and, as a result, can help to avoid serious damages. Such information is also useful for adapting and updating new and existing structures.

However, despite the wide range of practical applications of FOSS [4], a number of problems, especially for sensors embedded in the composite material, require additional theoretical and experimental studies. Therefore, the purpose of this study is to obtain theoretical (numerical modeling) and experimental results that ensure the reasonable use of FOSS based on Bragg gratings embedded in structures made of polymer and granular composite materials at the manufacturing stage to measure strains, including process-induced strains. Monitoring and reducing the level of process-induced strains in the resulting material will improve the quality and increase the further operation time of the object.

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