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Capability Study of Embedded Ultrasonic Transducer Microsystems for SHM Applications in Airplane Composite Structures

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An emerging trend in modern structure design is the combination of structures and sensors in order to measure environmental conditions and to evaluate structural integrity. One possible approach of this Structural Health Monitoring (SHM) paradigm is based on ultrasonic guided waves. These elastic waves interact with damages inside the structure and the evaluation of their echo response permits damage identification and localization. Typical applications are rotor blades of wind turbines made of GFRP and aircraft components made of CFRP.

The sensor nodes consist of small piezo transducers and sensor near electronics for signal processing, power supply, and wireless communication. The high demands for lifetime and reliability of the structure are directly transferred to the electronic microsystem. The authors are working on a novel approach to embed the sensor nodes into CFRP structures. Functionality, manufacturability and reliability were experimentally investigated and supported by numerical simulations. For this purpose material characterization of the layered composite structures has been conducted to provide material data for the calculations. Finite Element Simulations help to understand the structural mechanics during simultaneous sensor embedding and CFRP-lamination and were also applied to risk estimation in terms of sensor and electronics reliability. Elastodynamic Finite Integration Technique (EFIT) was applied to study guided wave propagation inside multilayer CFRP-structures and to determine the directivity pattern of sensors laminated inside or on the surface of CFRP panels. Various sensor integration concepts were modeled to study their influence on guided wave performance and sensitivity. Finally, the numerical results were compared to experimental wave field measurements based on non-contact laser vibrometry.

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Ключевые слова:

Содержание