Structural health monitoring by means of elastic wave propagation

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The scope of Structural Health Monitoring (SHM) includes constant monitoring of the structure's material condition (in real–time), for the elements of the structure as well as for the whole structure during its useful lifetime. The main goal of the SHM technique is to conduct research aimed at developing advanced non–destructive diagnostic methods of assessing integrity of diverse composite structures. Determining location, size and type of damage together with estimating the remaining operational lifespan of investigated structures is very important for assessing technical condition of many safety–critical machines and devices, as well as of means of transport (e.g. aircraft, helicopters, land and sea engineering structures).

Developing such methods and then applying them during construction and operation of composite structures allows for evaluating degradation, and therefore remaining life, of such structures. Application of the SHM methods is doubtlessly enable avoiding dangerous situations, and even more importantly, serious catastrophic scenarios.

Among various techniques available, a health monitoring system based on piezoelectric transducers and Lamb wave propagation seems to be a promising method for a quick and continuous inspection of metallic and composite structures.

Guided waves induced by piezoelectric transducers are extensively used for damage detection purpose. A numerical model based on time–domain spectral element method has been developed to simulate elastic wave propagation in metallic and composite structures induced by the piezoelectric transducers. Mathematical framework of 3D element formulation is given. The model solves the coupled electromechanical field equations simultaneously in 3D case. Moreover, numerical models constitute the foundation for developing perfect tools for designing and verifying new concepts of signal processing and testing methodology. Visualisation of elastic waves excited by the piezoelectric actuator in selected structures have been performed. Apart from visualisation of propagating waves also the interaction of elastic waves with various types of damage have been investigated.

Wide range of numerical simulations and experimental validations of analysed structures provide helpful information about dispersion, mode conversion, thermo–mechanical processes and wave scattering from stiffeners and boundaries. It can allow one to optimise excitation signal parameters and sensor placement, as well as enable analysis of signals reflected from damage.

The capability of employing two or more SHM techniques simultaneously in order to improve the overall performance of the process of assessing technical condition of the structure is also described.