Spatial Resolved Modelling and Measurement of Damage-Dependent Damping of Dynamically Loaded Multicomponent Materials

Klaudiusz Holeczek

The combination of the increasing economical demands and the high performance requirements of the aerospace and automotive applications lead to the design solutions containing extremely-loaded light components. The application of fibre reinforced composite materials in such structures became a state of the art during the last fifty years. This status is mainly caused by the outstanding mechanical properties of these modern materials compared with their monolithic contestants e.g. high specific strength and stiffness as well as programmable high damage tolerance. Besides these important mechanical properties, the layered architecture of this novel material group enables the integration of auxiliary elements into the material resulting in an extension of the application scope. Using properly selected and positioned sets of integrated sensing and actuating elements additional beneficial functions of the structure can be designed and implemented. One of such auxiliary tasks considered to be a very promising direction in the development of the future generation of advanced composite materials is the diagnostic function, used for the continuous monitoring of the structural integrity (Figure 1).

Diagnosed object	Diagnostic signal	Diagnostic feature	Diagnostic model	Diagnose
Condition of the structure e.g intact or damaged	Vibration signals e.g. displacement	Damage-sensitive parameters e.g. material damping	Quantitative relation between the diagnostic features and condition of the structure	Identification of a discrete damage condition

Fig. 1: Steps of vibration-based diagnostic procedure.

The diagnosis is performed based on the changes in mechanical parameters hence the proper selection of the measurable damage-dependent parameter plays a vital role. One of such parameters, identified as especially sensitive to different failure modes of fibre reinforced composites, is the material damping. A distribution of material damping for impacted carbon fibre reinforced composite plate determined in ultrasonic tests is presented on the figure 2.

The impacted region is characterised by a distinctive region with elevated acoustic impedance, which can be correlated to the increase in value of material damping. Hence in order to provide a reliable material damping-based diagnosis a change in value of local material damping should be utilised in order to assure reliable damage detection. The existing experimental methods for the determination of the local material damping are very limited regarding their spatial resolution and therefore do not allow a reliable determination of this mechanical parameter. In the ongoing investigations theoretical and experimental analysis of a new approach for the determination of local material damping changes is conducted.

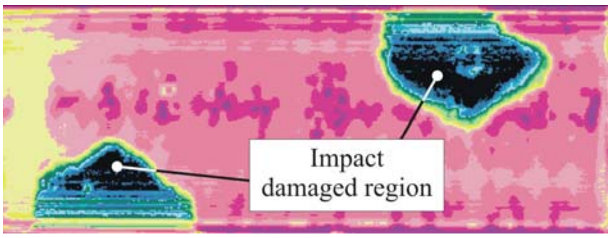

Fig. 2: Results of ultrasonic investigations of impact damaged carbon Results of ultrasonic investigations of impact damaged carbon fibre reinforced composite plate.