**Higher Order and Cell Type Finite Elements for the Simulation of Ultrasonic Waves in Lightweight Structures for Structural Health Monitoring (SHM)**

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ABSTRACT

The presentation shows the application of high frequency ultrasonic guided waves for monitoring the health state of thin-walled structures. Such waves can be excited with help of small and thin piezoelectric patch actuators. The signals are received at piezoelectric patch sensors which together constitute a network of actuators and sensors to monitor the health state of a structure. The traveling waves interact with damages, which results in reflections, transmissions and mode conversions of the waves. These changes can be recognized at the sensors, and, by comparing with base line measurements conclusions can be drawn about the health state of the structure. To design proper SHM systems finite element based simulation and optimization tools are required. Due to the high frequencies and the short wave length an enormous number of finite elements and a great computer power are needed to receive acceptable results. Commercial FEA tools, such as Ansys, Abaqus, Nastran etc., are not powerful enough to simulate the traveling waves in real size structures, such as airplane constructions. Therefore, special higher order finite elements have been developed, tested and applied. In the presentation the advantageous of these finite elements is shown, where the numerical results are also compared with measurements performed with help of 3D laser scanning vibrometry. If lightweight structures made from sandwich materials with a heterogeneous core layer have be analyzed the complexity of the models becomes even much higher. In the presentation it is shown, that in such applications the finite cell method is of great advantages, because the mesh has not to be body fitted. A regular cubic or tetrahedral mesh is sufficient. The real structure is taken into account only during the integration of the finite element/cell matrices. It is also possible to use measured data from computer tomography during the finite cell simulation. Some applications are presented to demonstrate the advantage and the quality the finite cell approach.

Brief CV

Ulrich Gabbert graduated at the Technische Hochschule Magdeburg as Mechanical Engineer (Dipl.-Ing.) with a specialization in steel construction and applied mechanics. The doctoral degree (Dr.-Ing.) he received in 1974. Then he was working as an engineer in a pump and compressor company in Halle, where he was responsible for the strength of materials, safety design and the development of simulation software. In 1979 he went back to the Technische Universität Magdeburg as Head of the Finite Element Development Group, responsible for finite element software developments and industrial applications. In 1988 he received the title doctor habilitatus (Dr.-Ing. habil.). Since 1992 he is Full University Professor at the University of Magdeburg. His research interests are finite elements, smart structures, active vibration and noise control, structural health monitoring and medical engineering. He is an active member of several national and international scientific organizations. In 2000 he received the Otto von Guericke Research Award*.*

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