On the determination of material degradation in composites by use of non-linear wave propagation analysis

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ABSTRACT

Fiber-reinforced plastics (FRP) are increasingly used in lightweight constructions. Due to improved but also more complex mechanical properties compared to conventional materials, there is a need to develop further advanced inspection methods for structures made of FRP. Microstructural damage in the matrix material as well as in the fiber matrix interface in the FRP component is difficult to detect by known non-destructive testing methods. Recent investigations show that guided waves are capable of detecting microstructural initial damage in FRP structures and are applicable for structural health monitoring, especially when nonlinear wave propagation and so-called higher harmonic wave modes are used. The method makes use of the fact that damaged structures behave in a nonlinear way. This inspection approach has been applied numerically and experimentally successfully for the detection of microstructural damages in isotropic materials [1]. Their applicability is currently expanded to fiber-reinforced plastics [2].

In the presentation, the applicability of nonlinear wave propagation is investigated for possible use as a non-destructive inspection method for FRP components. The focus is on the determination of the material degradation due to microstructural damage caused by cyclic tensile load in unidirectional carbon fiber-reinforced polymer (CFRP). Besides the experimental analysis, this study also includes the numerical simulation of the nonlinear wave propagation using a suitable hyper-elastic material law for FRP. The numerical and experimental investigations show that the use of nonlinear wave propagation in the generation of cumulatively higher harmonic modes is an appropriate tool to detect microstructural damages also in FRP components, e.g. due to fatigue phenomena [2]. Ongoing work is concerned with the extension of this methodology to other layered structures, e.g. cross-ply laminates and structures with more complex lay-ups.

REFERENCES
