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Investigation of the interaction forces in thin bonded interfaces in composite materials by nonlinear ultrasonic techniques

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Bonded interfaces in composite materials are elastic inhomogenieties, which influence the mechanical behavior of components under load significantly. Therefore, the investigation of the interaction forces in bonded interfaces is an important task in nondestructive materials testing. In general, binding forces are nonlinear and cause a nonlinear modulation of transmitted and reflected ultrasonic waves. As a consequence, the generation of higher harmonics of a monochromatic wave insonified onto an interface will give information about the binding forces /1-4/. For thin bonded interfaces, the local interaction forces, which may contain damping and hysteresis effects, can be imaged by the measured amplitudes and phases of the ultrasonic waves of the insonified frequency and its higher harmonics transmitted through the interface. Till now, the classical approximation is used which restricts the phases to special values and thus allows to determine non-hysteretical interaction force curves only from the measured amplitudes of the transmitted waves /2-4/. The investgation of binding forces in thin bonded interfaces yields not only the fundamentals to assess their bond quality but will also give information about nonlinear ultrasonic interactions in damaged materials containing micro-cracks, delaminations or similar soft inhomogeneities within a hard matrix material because these defects form contacts like weak bonds. That is, the results also help on the development of techniques for damage evaluation. An experimental problem is the fact, that nonlinearities are caused not only by bonded interfaces but also by the measuring system, the coupling medium, nonlinear behavior of the bonded components themselves, etc., which are in many cases larger than the wanted nonlinear signal from the interface. Systematic experimental and theoretical investigations are necessary to develop methods to minimize and/or separate the error effects and to assess the potentials and limitations of this nonlinear ultrasonic technique. Here, an important tool will be the numerical simulation of the experiments /5/.

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