NONLINEAR ELASTIC WAVE SPECTROSCOPY AS AN EFFECTIVE TOOL FOR NDE OF AERONAUTICAL STRUCTURES

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Nonlinear Elastic Wave Spectroscopy (NEWS) is very effective non-destructive testing method providing high sensitivity in incipient damage detecting. The main advantage of this methodology consists in the ability to detect small defects relatively far from ultrasonic actuators and sensors located on complex and thin extended structures. Two NEWS procedures - frequency mixing (NWMS) and time reversal (NLTRA) - were applied to reveal fatigue-induced cracks in the aircraft wing skin panel samples (Al-alloy sheets of 1.2mm thickness with riveted stringers and rib). Various configurations of piezoelectric transducer arrays were spaced on tested panels. Results obtained on damaged panels subjected to fatigue testing were compared with that on intact ones. Defect occurrence causes nonlinear effects changed with growing excitation. In NWMS procedure, we used two actuators and four sensors. First, “pumping” actuator was excited by lower frequency (50 kHz) higher power sinusoidal signals with gradually growing amplitude. Second, “probing” actuator, was excited by higher frequency (500 - 600 kHz) sinusoidal signal with constant amplitude. Nonlinear effects were observed on frequency spectra as inter-modulation side bands and growing odd harmonics. In NLTRA procedure, we used array of symmetrically spaced transducers with one or two transmitters and six receivers. Propagating elastic wave field, detected by the receiving array, was recorded, reversed in time and irradiated back toward the wave-generating source. In linear case, the irradiated field is focused back on the source and partially reconstructed. In media with nonlinearities, caused by defects, the time-reversed signals are concentrated around those nonlinearities and signal self-reconstruction is corrupted. Both procedures are mostly global in their simple realization, and reflect more or less only presence of defects without their localization. An attempt to localize fatigue cracks in damaged wing skin panels has been done using a comparison of nonlinearity parameters, evaluated on different wave paths (pseudo-tomography). High-voltage multiplexer was used to switch between transmitters and receivers in the transducer array. Directional dependence of evaluated nonlinearity parameters helped us to allocate zones with fatigue cracks or other nonlinearities caused by faulty riveted joints.

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