DISPERSION AND NONLINEARITY FOR SINGLE SOLITONIC PULSE ACOUSTIC PROPAGATION IN A COMPLEX SHAPE AERONAUTIC COMPOSITE MATERIAL

Serge Dos Santos[1], Sarka Vejvodova[2], Zdenek Prevorovsky[3]

[1]ENI Val de Loire, Unité Mixte de Recherche « Imagerie et Cerveau » INSERM U930 - CNRS ERL 3106, Université François Rabelais, Rue de la Chocolaterie BP 3410, F-41034 Blois cedex, serge.dossantos@univ-tours.fr, France,

[2]Czech Technical University, Faculty of Nuclear Sciences and Physical Engineering, Brehova 7, CZ-11519 Prague 1, sarka.vejvodova@centrum.cz, Czech Republic

[3]Institute of Thermomechanics AS CR, v.v.i., Dolejskova 5, CZ-18200 Prague 8, zp@it.cas.cz, Czech Republic

ABSTRACT

There is an increase in studying longitudinal bulk solitary waves in layered medium due to its potentiality to be applicable for the characterization of composites with complex inner structure and delamination process[1]. The understanding of wave propagation in microstructured materials opens the possibility to be applied for Nondestructive evaluation (NDE) of layered materials with the objective of imaging. The microstructure introduce dispersion effects in wave propagation, and can be associated to nonlinearity (induced by defects and degradation) in order to produce solitary waves. Stationarity properties of soliton propagation could be associated to stationarity properties of dispersion and nonlinearity. Consequently, if degradation process of the material occurs, the disequilibrium between nonlinearity and dispersion can be observed and the quality of soliton propagation could be used as a signature of the degradation of microstructural properties.

Preliminary experiments have been conducted on a 144 plies composite sample coming from aeronautic industry, having a complex geometry. Acoustic properties of the composite sample have been evaluated with an experimental set-up built with a pulse-echo ultrasonic device running at frequency between 150 kHz and 2.6 MHz. A power amplifier 150A100B device allows the propagation of nonlinear acoustic waves emitted with a Panametrics 1 MHz NDE transducer with a complex shape (Gaussian broadband solitons, chirp-coded, pulse inverted and Time Reversed) where received signals were analyzed with a home made 14 bits acquisition system at 10 MHz sampling frequency. Accurate post and pre processing, using arbitrary waveform generating devices allowing the possibility to perform TR-NEWS analysis[2] in the composite sample, has conducted to the measurement of dispersion effects of the longitudinal bulk celerity (around 2200 m/s) versus amplitude of acoustic waves emitted in the composite sample at frequencies between 400 and 900 kHz. Furthermore, the experimental validation of the virtual transducer concept[3] has been tested experimentally in the sample with the use of a bi-solitons excitation with the objective to measure the variation of the time delay in the bi-soliton shape versus microstructural properties of the dispersive composite.

REFERENCES

[1] A.M. Samsonov et al, *Elastic solitons in delaminated bars: splitting leads to fission, in Nonlinear Acoustics*—Fundamentals and Applications (ISNA 18), 18th International Symposium, American Institute of Physics, pp 307-310 (2008)

[2] J. Ulrich *et al*, Phys. Rev. Lett. 98, 104301 (2007); T. Goursolle *et al* . JASA, 122 (6), 3220-3229, (2007); A. Sutin *et al*, JASA, 125, 1906-1910 (2009); C. L. E. Bruno *et al*, Phys. Rev. B, 79, 064108 (2009)

[3] Z. Prevorovsky *et al*, in Proc of the ICU International Conference, Santiago de Chile, January 2009 ; S. Vejvodova *et al,* Nonlinear Time Reversal Tomography of Structural Defects, ICNEM, june 2009