Sideband Peak Count – a new nonlinear ultrasonic technique for monitoring damage progression in engineering materials

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Linear ultrasonic (LU) techniques used by majority of the researchers working in the area of material damage monitoring, are reliable for detecting relatively large defects. If the defect dimensions are in the range of the ultrasonic wavelength or larger, then those defects can be detected by analyzing the scattered ultrasonic fields. Material damage affects LU parameters such as ultrasonic wave speed and attenuation and their changes are detectable for relatively large defects. However, for small defects (when defect dimensions are significantly smaller than the wavelength of the propagating signal) the changes in the LU parameters are too small to detect or measure reliably. For detecting small defects engineers often use high frequency ultrasonic signals to make the defect dimensions greater than the wavelength. However, high frequency signals attenuate quickly and therefore, only very small regions near the ultrasonic probe can be inspected in this manner. Inspecting large structures by high frequency ultrasonic signals requires moving the probe mechanically from one point to the next and therefore, can be very time consuming. Nonlinear ultrasonic (NLU) technique on the other hand does not need to satisfy this restricting condition that the wave length of the signal has to be smaller than the defect size. NLU works well when the signal wavelength is much larger than the defect size. Therefore, relatively low frequency signals that can propagate a long distance and monitor a large area of a structure can be used for NLU measurements. Different NLU techniques can be used for detection and monitoring of small damages in a specimen. A relatively new NLU technique called the Sideband Peak Count-Index or SPC-I technique has been developed by the author and his colleagues. Its simplicity and other advantages have been discussed in their publications [1-21]. SPC-I technique for monitoring different types of materials – composites, metals, concrete, and other cement-based materials has been found to be effective. Along with those success stories of SPC-I the effect of topography and topological sensing will be discussed in this presentation. References: 1. Kundu, T., J. N. Eiras, W. Li, P. Liu, H. Sohn and J. Paya “Chapter 1: Fundamentals of Nonlinear Acoustical Techniques and Sideband Peak Count”, in Nonlinear Ultrasonic and Vibro-Acoustical Techniques for Nondestructive Evaluation, Ed. T. Kundu, Pub. Springer Nature, Switzerland, pp. 1-88, 2019. 2. Eiras, J. N., T. Kundu, M. Bonilla and J. Paya, "Nondestructive monitoring of ageing of alkali resistant glass fiber reinforced cement (GRC)", Journal of Nondestructive Evaluation, Vol. 32(3), pp. 300-314, 2013. 3. Liu, P., H. Sohn, T. Kundu and S. Yang, “Noncontact detection of fatigue cracks by laser nonlinear wave modulation spectroscopy (LNWMS)”, NDT&E International, DOI: 10.1016/j.ndteint.2014.06.002, Vol. 66, pp. 106-116, 2014. 4. Alnuaimi, H., U. Amjad, P. Russo, V. Lopresto and T. Kundu “Monitoring damage in composite plates from crack initiation to macro-crack propagation combining linear and nonlinear ultrasonic techniques” Structural Health Monitoring, An International Journal, Vol. 20(1), pp. 139-150, 2021. 5. Alnuaimi, H., S. Sasmal, U. Amjad, A. Hassani, L. Zhang and T. Kundu “Monitoring concrete curing by linear and nonlinear ultrasonic methods” ACI Structural and Materials Journal, Vol. 118(3), p.61-69, 2021. 6. Castellano, A., A. Fraddosio, M. D. Piccioni and T. Kundu, “Linear and nonlinear ultrasonic techniques for monitoring stress-induced damages in concrete” ASME Journal of Nondestructive Evaluation, Diagnostics and Prognostics of Engineering Systems, Vol. 4(4): 041001 (13 pages), 2021. 7. Basu, S., T. Arumaikani, S. Sasmal and T. Kundu, “Nonlinear ultrasonics based technique for monitoring damage progression in reinforced concrete structures” Ultrasonics, p. 106472, 2021. 8. Alnuaimi, H., U. Amjad, S. Park, P. Russo, V. Lopresto and T. Kundu, “An improved nonlinear ultrasonic technique for detecting and monitoring impact induced damage in composite plates”, Ultrasonics, Vol. 119, 106620, 2022. 9. Nikvar-Hassani, A. H. N. Alnuaimi, U. Amjad, S. Sasmal, L. Zhang and T. Kundu, “Alkali activated fly ash based concrete: evaluation of curing process using non-linear ultrasonic approach”, ASME Journal of Nondestructive Evaluation, Diagnostics and Prognostics of Engineering Systems, Vol. 5(2), p. 021006-1 to 5, 2022. 10. Park, S., H. Alnuaimi, A., Hayes, M. Sitkiewicz, U. Amjad, K. Muralidharan and T. Kundu, “Nonlinear acoustic technique for monitoring porosity in additively manufactured parts”, ASME Journal of Nondestructive Evaluation, Diagnostics and Prognostics

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