Ultrasonic Nonlinear Imaging within NDT 4.0 using

Prescriptive Signal, Image and Data Analysis

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Lisbon, March 4th 2022

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Abstract.

Today, Non-Destructive Testing (NDT) is the branch of science and engineering concerned with all methods of detecting and evaluating flaws in materials. Flaws can affect the serviceability of the material or structure, so NDT is important in guaranteeing safe operation as well as in quality control and assessing plant life. The flaws may be cracks or inclusions in welds and castings, or variations in structural properties which can lead to loss of strength or failure in service.

One of the strategic plan of the international NDT community is to define standards for developing advanced and digitalized automated NDT set-up in modern mass production, defining the concept of NDT 4.0 [1,2]. Furthermore, the growing interest for NDT methods based on nonlinear acoustic effects in solids has increased continuously since the first studies in the early 1980s. It has been shown that micro-inhomogeneities such as cracks lead to an anomalously high level of nonlinearity and dispersion, monitoring ageing of the material. In particular, nonlinear ultrasonic (US) has become increasingly important due to the increase of higher sensitivity of electronic instrumentation and its associate signal processing algorithms. NDT is now widely recognized as an own field of science and technology covering a very broad range of industrial applications. Instrumentation needs basics from applied physics and will concern all disciplines of engineering, including applied mathematics, computer science, modern automation and robotics for Industry 4.0. The nonlinearity of materials results in nonlinear effects, which arise from defects in the materials, usually considered as small signals or noise.

The main perspective of this keynote is to present a review of nonlinear US automated systems for contact and non-contact characterizations of materials and structures within modern NDT 4.0 based industries. The objective of this keynote is to prepare a guideline for application of this nonlinear US techniques within the context of Industry 4.0. The working plan is to analyze strengths, weaknesses; opportunities and threats (SWOT) within the area of experimental nonlinear NDT4.0. Challenges in development and deployment of relevant technologies are highlighted to identify engineering efforts required. The lecture presents this exciting range of nonlinear imaging highlighting their operation, analysis, design, control and applications.

During the second part of the keynote, the main activities conducted within the Academia NDT International will be presented in front of students and researchers highlighting its importance in arranging workshops in conjunction with international NDT events : ECNDT2014, WCNDT2016, ECNDT2018, WCNDT2020 in South Korea and ECNDT2023 in Lisbon, and . http://www.academia-ndt.org/

[1] Dos Santos, S. (2020). *Advanced Ground Truth Multimodal Imaging Using Time Reversal (TR) Based Nonlinear Elastic Wave Spectroscopy (NEWS): Medical Imaging Trends Versus Non-destructive Testing Applications*. In Recent Advances in Mathematics and Technology (pp. 55-87). Birkhäuser, Cham. https://link.springer.com/chapter/10.1007/978-3-030-35202-8_4

[2] Ripi Singh and Johannes Vrana, *"The World of NDE 4.0"* (2021)