Non-Contact Study of Heat-Treated Metallic Plates Using Acoustic Nonlinearity of Zero-Group-Velocity (ZGV) Lamb Modes

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The non-contact and nondestructive techniques for probing the quality of interface, adhesion, nonlinear phenomena, or local mechanical properties at micro-metric scale are of paramount importance in many applications, from advanced technologies at micro-metric and nano-metric scales to basic research such as evaluation of ultra-high pressure material properties.
In recent years, ZGV modes have proven to be an effective tool for locally and very accurately probing the thickness of a sample or the mechanical properties of isotropic or anisotropic materials. These particular types of guided waves, corresponding to local resonances of the inspected structure, are the results of the interference of two Lamb waves having an opposite phase velocity and coexisting to a single pair of frequency and wave number. The laser ultrasonic technique has demonstrated its ability to efficiently generate and detect such local resonances at frequencies in the range from a few tens to several hundreds MHz.
In this study, measurements of acoustic nonlinearity via contactless generation of ZGV Lamb waves are carried out in order to characterize the thermal aging of the aluminum alloy at the micro-metric scale. The experiments are realised on aluminum alloy specimens (Al6061-T6) which have been heat-treated at 220°C for different times (0 min, 20 min, 40 min, 1 h, 2 h, 10 h, 100 h, 1000 h) after solution heat treatment and had therefore the different levels of thermal aging. From the experimental observation, the fractional change in the acoustic nonlinearity agrees well with the variation in the yield strength, which demonstrates the potential capacity of the presented results for evaluating the thermal damages. Therefore, the variation of the acoustic nonlinearity could be considered as an indicator of the level of thermal aging of the aluminum alloy.