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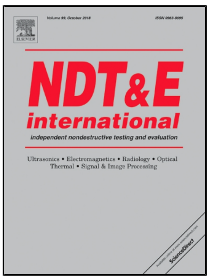

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Inversion Procedure for Dual-Mode Electromagnetic Nondestructive Characterization of Shot-Peened IN718

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Abstract The authors have recently developed a new technique for nondestructive Hall coefficient measurement based on inductive sensing of the Hall-Corbino current produced by injecting high-frequency alternating current into the component under test. This paper investigates the feasibility of separating the competing effects of near-surface residual stress and cold work in shot-peened fully hardened IN718 alloy in high-frequency dual-mode Hall impedance and eddy current conductivity measurements. For this purpose, an inversion procedure is proposed based on iterative application of a simplistic analytical approximation of the sought depth profiles. The inversion procedure was adapted to Hall coefficient depth profiling by accounting for the secondary eddy currents produced by the Hall-Corbino current at high frequencies. In order to test the accuracy of the proposed inversion procedure, representative Hall coefficient and electric conductivity distributions were selected based on typical residual stress and cold work depth profiles obtained by destructive XRD measurements. These distributions were calculated using gauge factors measured in previous studies that investigated the influence of applied elastic and plastic strain on the Hall coefficient and electric conductivity of fully hardened IN718. Numerical forward simulations were conducted to estimate the Hall impedance and apparent eddy current conductivity spectra produced by the selected elastic and plastic strain distributions. These spectra were then used as simulated "measured" data to test the inversion procedure. It was found, that the competing residual stress and cold work contributions of shot peening can be separated using dual-mode high-frequency inspection. The sub-surface peak compressive stress and half-peak depth of the residual stress profile were reproduced with less than ±50-100 MPa and ±5-10 μm errors, respectively, that is considered quite sufficient in subsurface residual stress profiling for life prediction purposes.

Keywords Hall effect; Corbino current; nondestructive evaluation, inductive sensing