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Micromagnetic Techniques for Characterization of Ferromagnetic Materials

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Abstract

Micromagnetic techniques for non-destructive evaluation exploit the abrupt local magnetization changes that arise within a ferromagnetic material subjected to an applied varying magnetic field. Measurement and analysis of induced signals are used to infer material condition or properties. Micromagnetic methods include magnetic Barkhausen noise (MBN) and magneto-acoustic emission (MAE). These techniques have been used in combination with other methods such as incremental permeability and upper harmonics analysis of the tangential magnetic field, for the characterization of material properties such as hardness, hardening depth, and yield and tensile strength of steel. The domain structure and its evolution by magnetization are affected by a host of material conditions and parameters including surface condition, grain size, carbon content, crystallographic texture, microstructure, domain wall pinning sites such as inclusions and dislocations, and the presence of residual stress and plastic deformation. In addition, the evolution of the domain structure is affected by the previous magnetization state, presence of DC bias fields as might arise due to remnant flux, rate of magnetization and peak magnetization level. The simultaneous dependence of domain structure evolution on multiple variables, produces a complex micromagnetic signal response. Therefore, acquisition of micromagnetic data requires consistency, and its interpretation necessitates consideration of all the variable parameters that may influence the inspection outcome. This presentation will examine a model that could be developed to account for a large number of parameters that influence the outcome of surface magnetic Barkhausen noise measurements under uniaxial elastic stress conditions.

Biography of Presenting Author

Thomas W. Krause received the B.Sc. degree from the University of Calgary, Calgary, AB, Canada, in 1987, and the M.Sc. and Ph.D. degrees from McMaster University, Hamilton, ON, Canada, in 1989 and 1992, respectively, all in physics. He was with the Applied Magnetics Group, Queen's University, Kingston, ON, Canada, from 1992 to 1996. In 1996, he held a position as Physicist with Canadian Nuclear Laboratories, developing non-destructive testing technology for the nuclear industry. In 2006 he accepted a position as Associate Professor with the Royal Military College of Canada. In 2008 he was promoted to full professor. He has 24 years of research and development experience on advanced NDT technology including pulsed eddy current, eddy current, magnetic Barkhausen noise, and ultrasonic testing of materials and structures. Dr. Krause is an expert in non-destructive testing (NDT) of materials using eddy current and ultrasonic techniques. R&D in NDT includes laboratory experimentation and computer modeling in the area of: Eddy current testing, Multi-frequency eddy current testing, Pulsed eddy current, Remote field eddy current, Probability of detection and Ultrasonic testing.

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