

REVIEW OF PROGRESS IN
QUANTITATIVE
NONDESTRUCTIVE
EVALUATION

San Diego, California 18 – 23 July 2010

■ **VOLUME 30 A**

EDITORS

Donald O. Thompson
Dale E. Chimenti

*Center for NDE and
Department of Aerospace Engineering,
Iowa State University*

AIP
American Institute
of Physics

Melville, New York, 2011

AIP I CONFERENCE PROCEEDINGS ■ 1335

Editors

Donald O. Thompson
Dale E. Chimenti

Center for NDE and Department of Aerospace Engineering
Iowa State University
Ames, IA 50011-3042
USA

E-mail: dthomps@cnde.iastate.edu
chimenti@cnde.iastate.edu

Authorization to photocopy items for internal or personal use, beyond the free copying permitted under the 1978 U.S. Copyright Law (see statement below), is granted by the American Institute of Physics for users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that the base fee of \$30.00 per copy is paid directly to CCC, 222 Rosewood Drive, Danvers, MA 01923, USA. For those organizations that have been granted a photocopy license by CCC, a separate system of payment has been arranged. The fee code for users of the Transactional Reporting Services is: 978-0-7354-0888-3/11/\$30.00

© 2011 American Institute of Physics

No claim is made to original U.S. Government works.

Permission is granted to quote from the AIP Conference Proceedings with the customary acknowledgment of the source. Republication of an article or portions thereof (e.g., extensive excerpts, figures, tables, etc.) in original form or in translation, as well as other types of reuse (e.g., in course packs) require formal permission from AIP and may be subject to fees. As a courtesy, the author of the original proceedings article should be informed of any request for republication/reuse. Permission may be obtained online using Rightslink. Locate the article online at <http://proceedings.aip.org>, then simply click on the Rightslink icon/"Permission for Reuse" link found in the article abstract. You may also address requests to: AIP Office of Rights and Permissions, Suite 1N01, 2 Huntington Quadrangle, Melville, NY 11747-4502, USA; Fax: 516-576-2450; Tel.: 516-576-2268; E-mail: rights@aip.org.

L.C. Catalog Card No. 2011900627
ISBN 978-0-7354-0888-3
ISSN 0094-243X
Printed in the United States of America

AIP Conference Proceedings, Volume 1335
Review of Progress in Quantitative Nondestructive Evaluation
Volume 30

Table of Contents

Preface	1
----------------	---

PART A

LESSONS LEARNED FROM THE I-35 BRIDGE COLLAPSE

I35W collapse, rebuild, and structural health monitoring: Challenges associated with structural health monitoring of bridge systems C. E. French, B. Hedegaard, C. K. Shield, and H. Stolarski	9
--	---

EMERGING TOOLS FOR SHM/PROGNOSIS

Application of an automated wireless structural monitoring system for long-span suspension bridges M. Kurata, J. P. Lynch, G. W. van der Linden, P. Hipley, and L.-H. Sheng	33
---	----

CHAPTER 1

ELASTIC AND INELASTIC WAVES

Section A. Ultrasonics-Modeling

Wave propagation in elastic medium with heterogeneous quadratic nonlinearity Guangxin Tang, Laurence J. Jacobs, and Jianmin Qu	43
3D image-based simulation for ultrasonic wave propagation in heterogeneous and anisotropic materials K. Nakahata, F. Schubert, and B. Köhler	51

Efficient finite element modeling of elastodynamic scattering from near surface and surface-breaking defects	
A. Velichko and P. D. Wilcox	59
Generic time-domain hybrid models for ultrasonic NDE	
Prabhu Rajagopal, Elizabeth Skelton, Michael Lowe, Richard Craster, and Jonathan Russell	67
A model of ultrasonic testing for cracks near a non-planar surface	
Jonathan Westlund and Anders Boström	75
Simulation of ultrasonic inspection involving multiple skips and realistic defects	
S. Chatillon, N. Leymarie, G. Rougeron, and S. Mahaut	83
An ultrasonic model for revealing electronic package's inner structure using acoustic impedance	
C. Xu, Z. Liu, J. Hao, and X. Zhao	91
Section B. Guided Waves-Fundamentals and Applications	
Scattering of plane guided waves obliquely incident on straight features	
P. D. Wilcox, A. Velichko, B. W. Drinkwater, A. J. Croxford, and M. D. Todd	97
The reflection of guided waves from simple supports in pipes	
A. Galvagni and P. Cawley	105
Boundary reflection compensation in guided wave baseline-free imaging	
Ross M. Levine, Jennifer E. Michaels, and Sang Jun Lee	113
The effect of complex defect profiles on the reflection of guided waves in pipes	
R. Carandente and P. Cawley	121
The reflection of the fundamental torsional mode from multiple small defects in pipes	
A. Løvstad and P. Cawley	129
Ultrasonic Rayleigh wave enhancements from angled defects in aluminum	
A. R. Clough, B. Dutton, and R. S. Edwards	137

Monitoring fatigue cracks in aluminum joints with ultrasonic guided waves	
H. Cho and C. J. Lissenden	145
Scattering of weld guided modes from defects located around the weld	
Z. Fan and M. J. S. Lowe	153
Acoustoelastic Lamb wave propagation in a homogeneous, isotropic aluminum plate	
Navneet Gandhi, Jennifer E. Michaels, and Sang Jun Lee	161
Air-coupled surface wave transmission measurement across a partially closed surface-breaking crack in concrete	
Seong-Hoon Kee and Jinying Zhu	169
Comparison of the effects of applied loads and temperature variations on guided wave propagation	
Sang Jun Lee, Navneet Gandhi, Jennifer E. Michaels, and Thomas E. Michaels	175
Hybrid safe/fe simulation of inspections of elastic waveguides containing several local discontinuities or defects	
V. Baronian, A. Lhémy, and K. Jezzine	183
Lamb-like wave mode selection algorithm for multilayer plate NDE	
H. Kannajosyula and C. J. Lissenden	191
Defect detection in multi-layered structures using high-frequency guided waves	
B. Masserey, E. Kostson, and P. Fromme	199
Experimental measurement and numerical simulation of fundamental anti-symmetric Lamb wave scattering in composites	
M. Veidt and C. T. Ng	207
Experimental results of guided wave travel time tomography	
Arno Volker and Joost Bloom	215
Guided wave travel time tomography for bends	
Arno Volker and Joost Bloom	223

In-line corrosion inspection using circumferential and longitudinal ultrasonic guided waves	
M. S. Lindsey, E. Khajeh, J. K. Van Velsor, C. J. Lissenden, and J. L. Rose	231

Section C. Laser Ultrasonics

Detection of shear and pressure waves in metals by dynamic wavelet fingerprinting in laser based ultrasonics	
N. N. Kishore, Aparna Gajendragadkar, Pankaj Gupta, and V. Raghuram	241

Defect detection using a scanning laser source	
S. E. Burrows and S. Dixon	249

Noncontact ultrasonic characterization of angled surface defects	
R. S. Edwards, B. Dutton, M. H. Rosli, and A. R. Clough	257

Nondestructive testing using two-component/two-wave mixing interferometer	
A. Wartelle, B. Pouet, and S. Breugnot	265

Determination of crystallographic texture in steel plates using laser-generated surface waves	
D. Lévesque, C. S. Lim, C. Padioleau, and A. Blouin	273

Defect detection on carbon fibre reinforced plastics (CFRP) with laser generated Lamb waves	
O. Focke, P. Huke, and A. Hildebrandt	281

Section D. Nonlinear Acoustics

On the efficient excitation of second harmonic generation using Lamb wave modes	
K. H. Matlack, J.-Y. Kim, L. J. Jacobs, and J. Qu	291

Nonlinear reflection of an obliquely incident longitudinal wave at a free surface	
F. A. Bender, J.-Y. Kim, L. J. Jacobs, and J. Qu	298

Measurements of nonlinear harmonic waves at cracked interfaces	
Hyunjo Jeong and Dan Barnard	306

Nonlinear guided waves in continuously welded rails for buckling prediction	
Robert Phillips, Ivan Bartoli, Stefano Coccia, Francesco Lanza di Scalea, Salvatore Salamone, Claudio Nucera, Mahmood Fateh, and Gary Carr	314
Measuring acoustic nonlinearity by collinear mixing waves	
M. Liu, G. Tang, L. J. Jacobs, and J. Qu	322
Nonlinear ultrasonic characterization using the noncollinear method	
A. J. Croxford, B. W. Drinkwater, and P. D. Wilcox	330
CHAPTER 2	
ELECTROMAGNETICS, THERMOGRAPHICS, AND THERMOSONICS	
Section A. Eddy Current Modeling and Probes	
Characterizing and modeling arrays of eddy-current probes	
Harold A. Sabbagh, R. Kim Murphy, Elias H. Sabbagh, John C. Aldrin, and Marcus Johnson	341
Low frequency eddy current benchmark study for model validation	
R. D. Mooers, M. R. Cherry, J. S. Knopp, J. C. Aldrin, H. A. Sabbagh, and T. R. Boehnlein	349
Low frequency eddy current finite element model validation and benchmark studies	
M. Cherry, R. Mooers, J. Knopp, J. C. Aldrin, H. A. Sabbagh, and T. Boehnlein	357
Modeling direct and inverse problems in ferritic heat-exchanger tubes	
Harold A. Sabbagh, R. Kim Murphy, Elias H. Sabbagh, and John C. Aldrin	365
Simulation for the assessment of wall thinning using eddy current method	
W. Cheng and I. Komura	372
Flux leakage measurements for defect characterization using a high precision 3-axial GMR magnetic sensor	
M. Pelkner, M. Blome, V. Reimund, H.-M. Thomas, and M. Kreutzbruck	380

Development and application of wide bandwidth magneto-resistive sensor based eddy current probe Buzz Wincheski and John Simpson	388
Section B. Thermographics, Thermosonics, and Applications	
The effects of crack opening and coatings on the detection capability of thermosonics B. Weekes, P. Cawley, and D. P. Almond	399
Crack imaging by scanning laser line thermography T. Li, D. P. Almond, and D. A. S. Rees	407
Crack detection using pulsed eddy current stimulated thermography E. Kostson, B. Weekes, D. P. Almond, J. Wilson, and G. Y. Tian	415
Characterization of piezoelectric stack actuators for vibrothermography Jyani Vaddi, Ricky Reusser, and Stephen D. Holland	423
Quantitative three-dimensional imaging by thermal tomography method J. G. Sun	430
Studying impact damage on carbon-fibre reinforced aircraft composite panels with Sonic IR Xiaoyan Han, Xinyue Zhao, Ding Zhang, Qi He, Yuyang Song, Anthony Lubowicki, G. Newaz, Lawrence D. Favro, and Robert L. Thomas	438
Quantitative infrared full-area imaging of coating thickness and integrity Harry I. Ringermacher, Donald R. Howard, and Bryon Knight	444
Thermography inspection for detection and tracking of composite cylinder damage during load testing J. N. Zalameda, W. P. Winfree, J. P. Seebo, and P. H. Johnston	450

Section C. X-ray and Terahertz

μ-Computed tomography for microstructure characterization of carbon fiber reinforced plastic (CFRP)	
R. Stoessel, T. Guenther, T. Dierig, K. Schladitz, M. Godehardt, P.-M. Kessling, and T. Fuchs	461
Sparse x-ray CT image reconstruction using ECME hard thresholding methods	
Kun Qiu and Aleksandar Dogandžić	469
A region of interest computed tomography technique for inspection of CFRP laminates	
S. Woods, M. Amos, I. Cooper, and P. Withers	477
Experimental scatter correction methods in industrial x-ray cone-beam CT	
K. Schörner, M. Goldammer, and J. Stephan	485
Optimum exposure conditions for computed radiography depending on fixed pattern noise and efficiency of imaging plate-scanner systems	
U. Ewert, K. Heyne, U. Zscherpel, M. Jechow, and K. Bavendiek	493
Backscatter x-ray development for space vehicle thermal protection systems	
Bence B. Bartha, Dale Hope, Paul Vona, Martin Born, and Tony Corak	501
X-ray backscatter imaging for aerospace applications	
Daniel Shedlock, Talion Edwards, and Chin Toh	509
Measurement and modeling of scatter ratios at high energies	
G.-R. Jaenisch, A. Deresch, C. Bellon, U. Ewert, and W. Przybilla	517
Intelligent system for radiogram analysis	
R. Sikora, T. Chady, P. Baniukiewicz, P. Łopato, L. Napierała, T. Pietrusewicz, G. Psuj, and B. Piekarczyk	525
An exploration of the utilities of terahertz waves for the NDE of composites	
David K. Hsu, Kwang-Hee Im, Chien-Ping Chiou, and Daniel J. Barnard	533

Time of Flight Diffraction (ToFD) with THz radiation—An alternative to the ultrasound-ToFD technique for nonmetallic materials U. Ewert, J. Beckmann, L. S. von Chrzanowski, G. Brekow, and D. Brackrock	541
CHAPTER 3	
SIGNAL PROCESSING, INVERSION, IMAGING, AND RECONSTRUCTION	
Section A. Signal Processing	
Some notes on the application of discrete wavelet transform in image processing Egydio C. S. Caria, Trajano A. de A. Costa, and João Marcos A. Rebello	551
Experimental noise injection in simulated model signals Tariq Khan, Lalita Udpa, and Satish Udpa	559
Duration and bandwidth of the signal components used in the analysis of impact-echo data D. Algernon and D. R. Hiltunen	567
Exploring the eddy current excitation invariance to infer about defect characteristics A. Lopes Ribeiro and H. G. Ramos	575
Signal modeling in the far-infrared region for nondestructive evaluation applications Chien-Ping Chiou, David K. Hsu, Dan Barnard, Kwang-Hee Im, and R. Bruce Thompson	581
A new processing method for saw resonator torque response signal C. Xu, Y. Zhang, S. Zhou, and X. Zhao	589
Signal evaluation system of flexible array ECT probes for inspecting complexly shaped surfaces H. Endo, A. Nishimizu, M. Tooma, H. Ouchi, I. Yoshida, Y. Nonaka, and K. Otani	597
Monte-Carlo inversion of travel-time data for the estimation of weld model parameters A. J. Hunter, B. W. Drinkwater, and P. D. Wilcox	604

A data-driven correction of ultrasonic source and receiver spectral amplitude variations	
P. J. S. van Capel, R. van Vossen, and A. W. F. Volker	612

Section B. Inversion

Solution of inverse problem using time reversal techniques	
S. Reyes-Rodríguez, C. Bardel, N. Lei, P. Roy, L. Udpa, S. S. Udpa, K. Arunachalam, K. Balasubramaniam, and C. V. Krishnamurthy	623

Uncertainty propagation in eddy current NDE inverse problems	
John C. Aldrin, Jeremy S. Knopp, Mark P. Blodgett, and Harold A. Sabbagh	631

Determination of the order of passes of an austenitic weld by optimization of an inversion process of ultrasound data	
C. Gueudré, L. Le Marrec, M. Chekroun, J. Moysan, B. Chassignole, and G. Corneloup	639

Multi-skip tomographic inversion	
Arno Volker, Joost Bloom, and Maarten Lorenz	647

Simulation of eddy current inspection including magnetic field sensor such as a giant magneto-resistance over planar stratified media components with embedded flaws	
Denis Prémel, J. M. Decitre, and G. Pichenot	655

Shape identification of pipe-wall thinning using electromagnetic acoustic transducer	
F. Kojima, T. D. Nguyen, and H. Yamaguchi	663

Section C. Flaw Characterization and Imaging

Characterization of a straight crack by performing measurements in two different directions	
Helena G. Ramos, Luka Kufrin, and A. L. Ribeiro	673

Surface-breaking crack depth assessment using near-field surface acoustic wave signal response	
James L. Blackshire and Aaron Modic	681

Flaw sizing in pipes using long-range guided wave testing	
R. M. Sanderson and P. P. Catton	689

Sizing disbonds between a stiffener and a composite plate using ultrasonic guided waves D. Singh and M. Castaings	697
Application of Bayesian approach for damage characterization in beams utilizing guided waves C. T. Ng, M. Veidt, and H. F. Lam	705
Defect imaging technique using a scanning laser source T. Hayashi, M. Murase, and T. Kitayama	713
Image-based fit modeling for coupled elastodynamic and acoustic problems K. Takata, K. Nakahata, F. Schubert, and B. Köhler	720
Improving synthetic aperture image by image compounding in beamforming process Oscar Martínez-Graullera, Ricardo T. Higuti, Carlos J. Martín, Luis G. Ullate, David Romero, and Montserrat Parrilla	728
Super-resolution imaging in elastic media T. Hutt and F. Simonetti	736
Time of flight diffraction and imaging (TOFDI) combining B-scans and cross-sectional imaging P. A. Petcher and S. Dixon	744
Capacitive imaging technique for NDE X. Yin and D. A. Hutchins	752

CHAPTER 4

ULTRASONIC TRANSDUCERS, PHASED ARRAYS, AND OTHER SENSORS

Section A. UT Transducers

Ultrasonic wave field modeling in a conical scanning probe tip Arthur Every, Ingo Wenke, Laurent Aebi, and Jurg Dual	763
Ultrasonic beam models for the generation of surface waves and plate waves with angle beam transducers Lester W. Schmerr Jr. and Alexander Sedov	771

Measurements to characterize acoustic distribution properties of ultrasonic transducer	
Tao Kong, Dingguo Xiao, and Chunguang Xu	779
Evaluation of electromagnetic acoustic transducer performance on steel materials	
R. Ribichini, F. Cegla, P. B. Nagy, and P. Cawley	785
Development of high temperature ultrasonic transducer for structural health monitoring	
A. Baba, C. T. Searfass, and B. R. Tittmann	793
Section B. Phased Arrays	
The ultrasonic measurement of crystallographic orientation for imaging anisotropic components with 2D arrays	
C. J. L. Lane, A. K. Dunhill, B. W. Drinkwater, and P. D. Wilcox	803
Development of a twin crystal membrane coupled conformable phased array for the inspection of austenitic welds	
J. Russell, R. Long, and P. Cawley	811
Variable split aperture processing of full matrix capture phased array data	
R. Long, P. Cawley, and J. Russell	819
Finite element analysis of ultrasonic phased array inspections on anisotropic welds	
G. Harvey, A. Tweedie, C. Carpentier, and P. Reynolds	827
Defect characterization using two-dimensional arrays	
A. Velichko and P. D. Wilcox	835
Comparison of the inspections of smooth and rough crack-like defects using ultrasonic arrays	
J. Zhang, B. W. Drinkwater, and P. D. Wilcox	843
Designing a calibrated full matrix capture based inspection	
D. Duxbury, J. Russell, and M. Lowe	851
Analysis of Distributed Sparse Array Configurations for Guided Wave Imaging Applications	
James S. Hall and Jennifer E. Michaels	859

Acoustic field calculation of ultrasonic linear phased array transducers with curve surface	
Chunguang Xu, Lijiu Wang, Dingguo Xiao, and Shiyuan Zhou	867
Phased array transducer for billet inspection	
R. A. Roberts, R. Bruce Thompson, Jeffrey A. Umbach, and Jon H. Friedl	874
Evolutionary technique for designing optimized arrays	
J. Villazón and A. Ibañez	882
Array imaging of noisy materials	
P. D. Wilcox	890
Method to simplify the beamforming process of multi-element synthetic aperture	
C. J. Martín, O. Martínez, D. Romero, M. Pérez, and L. G. Ullate	898
Simulation-based optimization of the design and settings of ultrasonic phased-array transducers with an evolutionary algorithm	
B. Puel, D. Lesselier, S. Chatillon, and P. Calmon	906

PART B

CHAPTER 5

ENGINEERED MATERIALS

Section A. Composites

Use of Modal Acoustic Emission to Monitor Damage Progression in Carbon Fiber/Epoxy Composites	
J. M. Waller, C. T. Nichols, D. J. Wentzel, and R. L. Saulsberry	919
Fatigue damage identification in composite structures through ultrasonics and wavelet transform signal processing	
V. La Saponara, W. Lestari, C. Winkelmann, L. Arronche, and H.-Y. Tang	927
Nondestructive inspection of a composite material sample using a laser ultrasonics system with a beam homogenizer	
J. M. S. Sakamoto, A. Baba, B. R. Tittmann, J. Mulry, M. Kropf, and G. M. Pacheco	935

Flaw detection in a multi-material multi-layered composite: Using FEM and air-coupled UT	
R. A. Livings, V. Dayal, D. J. Barnard, and D. K. Hsu	942
Characterization of material degradation in ceramic matrix composites using infrared reflectance spectroscopy	
Adam T. Cooney, Richard Y. Flattum-Riemers, and Benjamin J. Scott	950
Characterization of waviness in wind turbine blades using air coupled ultrasonics	
Sunil Kishore Chakrapani, Vinay Dayal, David K. Hsu, Daniel J. Barnard, and Andrew Gross	956
Section B. Armor Materials	
Low velocity impact testing and nondestructive evaluation of transparent materials	
R. E. Brennan and W. H. Green	965
Ultrasound nondestructive characterization of transparent spinel	
S. Bottiglieri, A. R. Portune, and R. A. Haber	973
NDT Characterization of boron carbide for ballistic applications	
D. Liaptsis, I. Cooper, N. Ludford, A. Gunner, Mike Williams, and David Willis	981
Nondestructive characterization of AS-fabricated composite ceramic panels	
W. H. Green and R. E. Brennan	989
A more comprehensive NDE: PCRT for ceramic components	
Leanne Jauriqui and Lem Hunter	997
NDE of hybrid armor structures using acoustography	
Jaswinder S. Sandhu and Charles G. Pergantis	1005
Simulation tools for ultrasonic inspections of multi-layer armor panels	
Nathaniel Richter, Frank J. Margetan, Tim Gray, and R. Bruce Thompson	1013
Miniaturized hand held microwave interference scanning system for NDE of dielectric armor and armor systems	
Karl F. Schmidt, Jack R. Little, William A. Ellingson, Thomas J. Meitzler, and William Green	1021

Line scanning thermography for rapid nondestructive inspection of large scale composites	
S. Chung, O. Ley, V. Godinez, and B. Bandos	1029
Porosity detection in ceramic armor tiles via ultrasonic time-of-flight	
Frank J. Margetan, Nathaniel Richter, and Terrence Jensen	1037
Simple go/no-go test for subcritical damage in body armor panels	
Jason Fisher and D. E. Chimenti	1045

Section C. Welds and Bonds

Inspection of nickel alloy welds: Results from five-year international program	
Iouri Prokofiev, Stephen E. Cumblidge, and Steven R. Doctor	1055
A study into the effects of an austenitic weld on ultrasonic array imaging performance	
A. J. Hunter, B. W. Drinkwater, J. Zhang, and P. D. Wilcox	1063
SH Guided waves to infer the shear stiffness of adhesive bonds	
M. Castaings and B. Le Crom	1071
Ultrasonic characterization of interfaces in composite bonds	
N. Wang, O. I. Lobkis, S. I. Rokhlin, and J. H. Cantrell	1079

CHAPTER 6

MATERIALS CHARACTERIZATION

Section A. Microstructure and Material State

Methods for the in-situ characterization of cast austenitic stainless steel microstructures	
P. Ramuhalli, M.S. Good, R.J. Harris, L.J. Bond, C.O. Ruud, A.A. Diaz, and M. T. Anderson	1089
Microstructure characterization and imaging of fine-grained steel by microscopic ultrasonic techniques	
S. Hirsekorn, U. Rabe, L. Batista, and L. Behl	1097

Characterization of cast iron microstructure through the statistical fluctuation and fractal analyses of ultrasonic backscattered signals E. P. de Moura, P. G. Normando, L. L. Gonçalves, and S. E. Kruger	1104
Assessment of microstructure in grade T22 Cr-Mo steel by nondestructive tools P. Kiattisaksri, S. Meir, J. Poncelow, J. C. Madeni, R. L. Hellner, K. Coleman, S. Liu, B. Mishra, and D. L. Olson	1112
Assessment of steel microstructure evolution during thermal treatment by magnetic and electronic techniques S. Meir, D. L. Olson, B. Mishra, S. Liu, K. Coleman, and R. Hellner	1120
Evolution of recrystallization by changes in magnetic hysteresis loop in a non-oriented electric steel cold rolled F. E. da Silva, F. N. C. Freitas, H. F. G. Abreu, L. L. Gonçalves, E. P. Moura, and M. R. Silva	1128
Ultrasonic backscattering in polycrystalline materials of PWR components B. Chassignole, O. Dupond, T. Fouquet, and F. Rupin	1136
Nondestructive evaluation of dual microstructure turbine engine disk material E. A. Medina, M. P. Blodgett, R. W. Martin, and S. Sathish	1144
Material state prognosis through the identification of material parameters used in thermo-mechanical constitutive models Ketan A. Nayak, Krishnan Balasubramaniam, and C. V. Krishnamurthy	1152
Section B. Material Properties	
A fundamental analysis of low frequency impedance phenomenon: Application to hydrogen content assessment of coated linepipe steel weldments K. Koenig, A. N. Lasseigne, J. E. Jackson, D. L. Olson, and B. Mishra	1163
Submerged eddy current method of hydrogen content evaluation of zircaloy-4 fuel cladding E. A. Pfeif, Z. Jones, A. N. Lasseigne, K. Koenig, K. Krzywosz, E. V. Mader, S. Yagnik, B. Mishra, and D. L. Olson	1168
Liquid steel cleanliness measurement: Numerical analysis of probe design H. Y. Cui, J. Trevelyan, S. Millman, and S. Johnstone	1176

Electrochemical characterization of a low modulus Ti-35.5Nb-7.3Zr-5.7Ta alloy in a simulated body fluid using EIS for biomedical applications	
R. Bhola, S. M. Bhola, B. Mishra, R.A. Ayers, and D.L. Olson	1184
Ultrasonic properties of Low Solvus High Refractory (LSHR) super alloy disk material	
Jeong K. Na and Mark Blodgett	1192
Advanced nondestructive assessment technology to determine the aging of silicon containing materials for generation IV nuclear reactors	
T. W. Koenig, D. L. Olson, B. Mishra, J. C. King, J. Fletcher, L. Gerstenberger, S. Lawrence, A. Martin, C. Mejia, M. K. Meyer, R. Kennedy, L. Hu, G. Kohse, and J. Terry	1200
Nondestructive evaluation of Ni-Ti shape memory alloy	
S. Meir, S. Gordon, M. Karsh, A. Wiezman, R. Ayers, and D. L. Olson	1208
Evaluation of surface hardening by measuring magnetic properties	
Y. Tsuchida, T. Matsuda, and M. Enokizono	1216
Section C. Fatigue, Creep, Corrosion, and Stress	
The fatigue evaluation method for a structural stainless steel using the magnetic sensor composed of three pancake coils	
M. Oka, Y. Tsuchida, T. Yakushiji, and M. Enokizono	1225
Material gauge factor of directional electric potential drop sensors for creep monitoring	
E. Madhi and P. B. Nagy	1233
Study of corrosion of super martensitic stainless steel under alternating current in artificial seawater with electrochemical impedance spectroscopy	
T. Reyes, S. Bhola, D. L. Olson, and B. Mishra	1241
Characterization of residual stresses in ferrous components by magnetic anisotropy measurements using a Hall effect sensor array probe	
C. C. H. Lo	1249
Complementary electromagnetic nondestructive evaluation	
Gui Yun Tian, John Wilson, and Maxim Morozov	1256

Section D. Civil Materials

Characterization of alkali-silica reaction in concrete specimens using a nonlinear vibration technique	
Krzysztof J. Lesnicki, Jin-Yeon Kim, Kimberly Kurtis, and L. J. Jacobs	1267
NDT techniques for characterizing alkali-silica reaction in standard concrete specimens—A review	
J. Chen, K. J. Lesnicki, K. E. Kurtis, J.-Y. Kim, and Laurence J. Jacobs	1275
Monitoring damage in concrete using diffuse ultrasonic coda wave interferometry	
Dennis P. Schurr, Jin-Yeon Kim, Karim G. Sabra, and Laurence J. Jacobs	1283
Following stress level modification of real size concrete structures with coda wave interferometry (CWI)	
Y. Zhang, O. Abraham, E. Larose, T. Planes, A. Le Duff, B. Lascoup, V. Tournat, R. El Guerjouma, L.-M Cottineau, and O. Durand	1291
Basic study and application for ultrasound dispersion in concrete structures	
T. Mihara, M. Maruta, T. Hamajima, Y. Udagawa, and H. Tashiro	1299
NDT data fusion for evaluating concrete structures	
M. A. Ploix, V. Garnier, D. Breyse, and J. Moysan	1307
Imaging laser analysis of building materials—Practical examples	
G. Wilsch, D. Schaurich, and H. Wiggenhauser	1315

CHAPTER 7

PROCESS CONTROL, CIVIL STRUCTURES, AND STRUCTURAL HEALTH MONITORING:

Section A. Process Control

Ultrasonic wall thickness monitoring at high temperatures (> 500°C)	
F. B. Cegla, J. O. Allin, J. O. Davies, P. Collins, and P. Cawley	1325
Ultrasonic measurement of erosion/corrosion rates in industrial piping systems	
A. N. Sinclair, V. Safavi, and F. Honarvar	1333

Continuous surveillance technique for flow accelerated corrosion of pipe wall using electromagnetic acoustic transducer F. Kojima, D. Kosaka, and K. Umetani	1341
Threshold choice in image processing Rômulo M. Almeida and João Marcos A. Rebello	1347
Structural integrity assessment using Process Compensated Resonant Testing (PCRT) Surendra Singh, Leanne Jauriqui, Eric Biedermann, Eric Yen, Daniel Cabrera, Larry Whalen, David Piotrowski, and David Heck	1355
Section B. NDE for Civil Structures	
Modification of the zero group velocity (impact echo) resonance frequency in the presence of voids for the inspection of tendon ducts O. Abraham, J. S. Popovics, and L.-M. Cottineau	1365
Monitoring of reinforced concrete corrosion and deterioration by periodic multi-sensor nondestructive evaluation R. W. Arndt, J. Cui, and D. R. Huston	1371
Acoustoelastic effects on the natural frequencies of pre-stressed concrete beams N. Ryden, L. Lundqvist, and S. Thelandersson	1379
Monitoring of concrete structures using OFDR technique J. M. Henault, J. Salin, G. Moreau, S. Delepine-Lesoille, J. Bertand, F. Taillade, M. Quiertant, and K. Benzarti	1386
On-site evaluation of large components using SAFT and TOFD ultrasonic imaging M. Spies, H. Rieder, and A. Dillhöfer	1394
Real time damage detection system using guided waves in ACSR cables R. Mijarez, F. Martinez, and A. Baltazar	1402
Acoustic emission monitoring for assessment of steel bridge details D. E. Kosnik, T. Hopwood, and D. J. Corr	1410
Dynamic strain sensing in a long-span suspension bridge using fiber Bragg grating sensors Yinian Zhu, Yan-Jin Zhu, Oluwaseyi Balogun, Songye Zhu, You-Lin Xu, and Sridhar Krishnaswamy	1418

Numerical studies on the acoustic field generated by a dipole source in noncircular pipes	1424
Hailan Zhang, Weijun Lin, and Xiuming Wang	
Pulse-echo phased array ultrasonic inspection of Pultruded Rod Stitched Efficient Unitized Structure (PRSEUS)	1432
P. H. Johnston	
The application of phased array ultrasonic techniques for inspection of railway axles from their end face	1440
D. Liaptsis, I. Cooper, K. Boyle, and P. I. Nicholson	
NDT Validation facility at the Florida Department of Transportation	1448
D. Algernon, D. R. Hiltunen, C. C. Ferraro, and C.A. Ishee	
Section C. Structural Health Monitoring	
Development of a stamp size pulser-receiver for structural health monitoring applications	1459
M. Janardhan Padiyar, C. V. Krishnamurthy, and K. Balasubramaniam	
Diagnostic and prognostic tools for residual life estimation in aging nuclear power plant components	1467
P. Ramuhalli, L. J. Bond, J. Griffin, C. Henager Jr., and M. Dixit	
Guided wave ultrasound field mapping using a network of removable Bragg grating transducers	1475
Indu Fiesler Saxena, Narciso Guzman, Kaleonui Hui, Lothar U. Kempen, and Ajit K. Mal	
Interaction of guided Lamb waves with delaminations and discontinuities in composite plate-like structures	1483
Krishnan Balasubramaniam, C. Ramadas, Janardhan Padiyar, and C. V. Krishnamurthy	
Application of IDT sensors for structural health monitoring of windmill turbine blades made of composite material	1491
V. Nalladega, J. K. Na, and C. Druffner	
Quantitative enhancement of fatigue crack monitoring by imaging surface acoustic wave reflection in a space-cycle-load domain	1499
G. D. Connolly and S. I. Rokhlin	

SHM of large structures using guided waves for crack detection P. Fromme	1507
Impact of applied loads on guided wave structural health monitoring Jennifer E. Michaels, Sang Jun Lee, and Thomas E. Michaels	1515
Imaging of a defect in thin plates using the time reversal of single mode Lamb waves Hyunjo Jeong, Jung-Sik Lee, and Sung-Min Bae	1523
CHAPTER 8	
POD, NEW SENSORS, TECHNIQUES AND SYSTEMS, AND BENCHMARK COMPARISONS	
Section A. POD and Reliability	
POD of ultrasonic detection of synthetic hard alpha inclusions in titanium aircraft engine forgings R. B. Thompson, W. Q. Meeker, and L. J. H. Brasche	1533
Physical model assisted probability of detection in nondestructive evaluation M. Li, W. Q. Meeker, and R. B. Thompson	1541
Probability of detection of surface defects in metals using optical inspection techniques M. Rauhut, M. Spies, and K. Taebner	1549
Nonparametric POD estimation for hit/miss data: A goodness of fit comparison for parametric models Floyd W. Spencer	1557
Recent advances in modeling discontinuities in anisotropic and heterogeneous materials in eddy current NDE John C. Aldrin, Harold A. Sabbagh, R. Kim Murphy, and Elias H. Sabbagh	1565
Simulation supported POD: Methodology and HFET validation case F. Jenson, E. Iakovleva, and N. Dominguez	1573
Early work on the use of models in the determination of POD/inspection reliability in the U.S. and U.K. R. Bruce Thompson	1581

Case studies for model-assisted probabilistic reliability assessment for structural health monitoring systems	
John C. Aldrin, Enrique A. Medina, Eric A. Lindgren, Charles F. Buynak, and Jeremy S. Knopp	1589
Development of rapid, continuous calibration techniques and implementation as a prototype system for civil engineering materials evaluation	
M. L. Scott, N. Gagarin, J. R. Mekemson, and S. R. Chintakunta	1597
Recent improvements in display and analysis of NDE data at NASA	
D. J. Roth, R. W. Rauser, A. Abdul-Aziz, R. Cotton, E. Burke, S. Zhang, M. Marsh, B. A. Davis, and G. F. Studor	1605
Classification procedure in limited angle tomography system	
W. Chlewicki, P. Baniukiewicz, T. Chady, and A. Brykalski	1613
Section B. Sensors and Sensor Materials	
Geometrical gauge factor of directional electric potential drop sensors for creep monitoring	
E. Madhi and P. B. Nagy	1623
In-situ creep monitoring using the potential drop method	
E. Madhi, G. Sposito, C. M. Davies, P. Cawley, and P. B. Nagy	1631
Development of ultrasonic surface wave sensors for structural health monitoring of composite wind turbine blades	
C. Druffner, V. Nalladega, and J. K. Na	1639
Analysis of a concentric coplanar capacitive sensor using a spectral domain approach	
Tianming Chen, Jiming Song, John R. Bowler, and Nicola Bowler	1647
Development of a novel ultrasonic waveguide transducer for under-sodium viewing	
K. Wang, H. T. Chien, W. P. Lawrence, D. Engel, and S. H. Sheen	1655
Piezoelectric behaviour of sputtered aluminium nitride thin film for high frequency ultrasonic sensors	
T. Herzog, S. Walter, H. Bartzsch, M. Gittner, D. Gloess, and H. Heuer	1663

Piezoelectric material for use in harsh environments D. A. Parks and B. R. Tittmann	1671
Section C. New Techniques and Systems	
Defect monitoring at elevated temperatures (> 500°C) using an array of ultrasonic waveguides A. J. C. Jarvis and F. B. Cegla	1679
Technique for imaging using virtual array of sources (TIVAS) S. Alavudeen, C. V. Krishnamurthy, and Krishnan Balasubramaniam	1687
Potential of ultrasounds for NDT of a structure located behind parallel immersed plates G. Corneloup, M.-A. Ploix, J.-F. Chaix, I. Lillamand, and F. Baqué	1695
Evaluation of outer flaws in titanium alloys using eddy current measuring system T. Chady, G. Psuj, and J. Kowalczyk	1701
Extremely short impulse eddy current system for titanium and inconel samples testing T. Chady and P. Frankowski	1709
Use of microwaves for the detection of corrosion under insulation: A sensitivity study R. E. Jones, F. Simonetti, M. J. S. Lowe, and I. P. Bradley	1714
Microwave interferometer for shock wave induced displacement measurement J. Choi, G. Youssef, S. Breugnot, V. Gupta, and T. Itoh	1722
Crack detection using induction thermography for thermomechanical fatigue tests M. Genest, D. C. Dudzinski, S. Bulmer, and R. K. Kersey	1727
Automatic magnetic particle inspection system for the bracket welds of Atucha I nuclear power plant pressure vessel P. Katchadjian, C. Desimone, A. Garcia, C. Antonaccio, F. Schroeter, and P. Mastroleonardo	1735

Development of a portable mechanical hysteresis measurement and imaging system for impact characterization in honeycomb sandwich structures	1743
Daniel J. Barnard and David K. Hsu	
Feedback algorithm for simulation of multi-segmented cracks	1751
T. Chady and L. Napierała	
Wireless NDE sensor system for continuous monitoring	1758
G. Dib, L. Mhamdi, T. Khan, L. Udpa, N. Lajnef, J.-W. Hong, S. Udpa, P. Ramuhalli, and K. Balasubramaniam	
Section D. Benchmark Comparisons	
Developing and using benchmarks for eddy current simulation codes validation to address industrial issues	1769
M. Mayos, F. Buvat, V. Costan, O. Moreau, C. Gilles-Pascaud, C. Reboud, and F. Foucher	
Results of the 2010 UT modeling benchmark obtained with CIVA: Responses of backwall and surface breaking notches	1777
R. Raillon, S. Bey, A. Dubois, S. Mahaut, and M. Darmon	
Magnetic flux leakage: A benchmark problem	1785
J. I. Etcheverry, G. A. Sánchez, and N. Bonadeo	
Validation of magnetic flux leakage computational results against experimental data	1792
J. I. Etcheverry and G. A. Sánchez	
Attendees List	1799
Author Index	1821
Subject Index	1832