Abstract list of Workshop 2001

Review of Some Measurement Techniques Involved in Modern NDE (Keynote Lecture)

By R. Stoessel, K. Pfleiderer, H. Gerhard, S. Predak, N. Krohn, A. Dillenz, Th. Zweschper, G. Busse

Institute of Polymer Testing and Polymer Science (IKP)-Nondestructive Testing – (IKP-ZFP)
University of Stuttgart, Pfaffenwaldring 32, D-70569
Stuttgart, Germany

Abstract

The broad variety of modern materials together with demanding applications requires reliable inspection techniques for components with respect to defects caused by the manufacturing process or damage occurring later. The combination of basic research and application-oriented investigations results in the development of methods for nondestructive evaluation (NDE) that allow for sensitive inspection even under rough conditions. This article presents principles and applications for some methods.

Keywords

Microwaves, air-ultrasound, non-linear imaging, laser-vibrometry, elastic wave thermography, burst phase ultra-sound thermography, polymers, laser welding, cracks, disbond, laminates, adaptive structures

Deconvolution of NDE Signals

By T. Olofsson, T. Stepinski

Signals and Systems Group,
Uppsala University, Box 528, 751 20
Uppsala, Sweden

Abstract

A tutorial is given on deconvolution of ultrasonic pulse-echo signals in nondestructive evaluation. The goal with the deconvolution is to obtain signals that only in minimal degree depend on the transducer characteristics. The deconvolution problem is formulated as estimation of the reflection sequence, i.e., the impulse response characterizing the inspected object. A maximum a *posteriori* framework is used for explaining relations between various deconvolution methods. The differences between the methods are explained in terms of different prior amplitude distributions describing the reflection sequence and yielding different optimization criteria, as well as in terms of different methods used for optimizing these criteria. To illustrate the ideas, three cases of prior amplitude distributions are treated: first, a Gaussian distribution is used to model dense scatterers. This yields a solution that is identical or closely related to the classical Wiener filter. Second, layered materials containing negligible amount of scatterers are modeled using a Bernoulli-Gaussian distribution and this leads to sparse deconvolution methods. Finally, a number of possible distributions for modeling layered materials giving rise to non-negligible scattering are presented, leading to semi-sparse deconvolution methods. Theoretical results are illustrated using simulated data and examples from NDE applications.

Keywords

Deconvolution, estimation, ultrasonic pulse-echo testing

Inverse Problems by Genetic Algorithms:

Application to the Photothermal Depth Profiling

By R. Li Voti

INFM and Dipartimento di Energetica, Università degli Studi di Roma "La Sapienza",
Via Scarpa 14, 00161 Roma, Italy,
Fax: +39.06.44240183, Email: Roberto.livoti@uniroma1.it

Abstract

In this article we want to discuss the use of the Genetic Algorithms to solve inverse problems. The basic mechanisms are explained in details and clarified by a simple example taken from the mathematics. As a second example, take from the applied physics, we discuss how to apply Genetic Algorithms to the photothermal depth profiling, to determine the thermal conductivity in inhomogeneous samples. We show some typical numerical results, discussing the role of the critical parameters, analyze the sensitivity to the noise, and present some experimental results on a hardened steel sample.

Keywords

Genetic algorithms, inverse problems, photothermal depth profiling, radiometry

Artificial Intelligence in NDE

By C.H. Chen

University of Massachusetts Darmouth, Electrical and Computer Engineering Dept.
285 Old Westport Road, N. Darmouth, MA 02747-2300 UA,
Email: cchen@umassd.edu

Abstract

This paper presents an overview of the use of artificial intelligence principles in nondestructive evaluation. Topics examined include expert systems, decision making process, Bayes networks, Dempster-Shafer theory and fuzzy logic in NDE, knowledge discovery, and computer vision for NDE. Although AI in NDE is still in its infancy, many AAI ideas, techniques and software products are potentially very useful to building intelligent NDE systems.

Ion Implantation Dose High-Resolution Monitoring in Si Wafers using Laser Infrared Photothermal Radiometry with Lock-in Common-mode-rejection Demodulation

By A. Mandelis*, F. Rabago**

*Photothermal and Optoelectronic Diagnotics Laboratories,
Dept. of Mechanical and Industrial Engineering,
University of Toronto, Toronto M5S 3G8, Canada
**Universidad Autonoma di San Luis Potosi, S.L.P., Mexico

Abstract

Frequency-scanned and lock-in common-mode-rejection demodulation schemes were used with laser infrared Photothermal radiometric (PTR) detection of B^+, P^+, and As^+ ion-implanted Si wafers, with or without surface-grown oxides. The implantation energy was 100 keV with doses in the range $1x10^{11}$ – $1x10^{13}$ ions/cm^2. The lock-in common-mode-rejection demodulation (CMRD) scheme exhibited superior signal resolution in all cases where the conventional frequency-scan signals were essentially overlapped. It was further established that the pulse separation increment $\delta\Delta$ is the critical CMRD waveform parameter, which controls dose resolution through substantial signal background and noise suppression.

Keywords

Semiconductors, Photothermal, radiometry, lock-in amplifier, common-mode-rejection, demodulation, waveform engineering, ion implantation

Reliability Investigation of NDE Signals

By CH. Müller, U. Zscherpel, U. Ewert, M. Scharmach, C. Bellon, G.R. Tillack

Federal Institute for Materials Research and Testing (BAM),
D-12200, Berlin, Germany

Abstract

The reliability investigations are dedicated to throw light on the performance of the NDE system with respect to the required aim. This is especially of interest when digitized and processed signals are involved where it becomes hard to assess whether the quality of the system has raised or not. Three different ways to investigate reliability of NDE signals will be described. The first way of investigation, the performance demonstration, is preferred e.g. in the US American nuclear power industry. This is an integral consideration of the non destructive test as a system where the whole NDE system is packed in a black box and only the input in terms of the real existing flaws in the component is considered and compared to the output in terms of the indications of the human inspector or of the automated system. The second – the European tradition – relies on a standardized description of physical/technical parameters of the NDE system which are preconditions for successful system performance. An example for such a standardized set of performance parameters is given in the recently released standard about X-ray film digitization CEN EN 14096. The third approach – the modular conception – is a marriage of both: The signal chain is cut into main modules. Each module is assessed in a most appropriate individual way e.g. via modeling calculations. The single results are joint together according to the reliability of the subsystems. Separating criteria for the system were proposed through a reliability formula developed during a series of European-American workshops on NDE reliability. Examples of all three approaches will be given.

Keywords

Reliability of NDE Systems, Performance Demonstration, Essential Parameters, European Standards, Radiographic Testing, Film Digitization, Austenitic Tube Welds, ROC, POD, Modular Approach, European-American Workshops on NDE Reliability, Reliability Formula

Nonlinear Acoustic Imaging Tutorial

By R.Gr. Maev

Physics Department, School of Physical Sciences,
University of Windsor, Ontario, N9B 3P4 Canada

Abstract

An obvious implication of the higher harmonic generation of acoustic imaging in the nonlinear medium is an improvement of an image resolution for a focused acoustic beam configuration. Another important conclusion from the various recent results presented by different research groups is that the contrast of the nonlinear acoustic image is determined by local material nonlinearity and can be substantially enhanced in the presence of micro-inhomogeneous defects. A high local nonlinearity of micro-inhomogeneities can be used for parametric modulation of the material properties (by a pump wave) in the defected areas “read” by another acoustic wave. Some new opportunities for the nonlinear material characterization using such parametric acoustic imaging will be also discussed. Improvement of imaging resolution using higher harmonics is on the discussion and one of the priorities on this way.

Keywords

Nonlinear acoustic imaging, ultrasonic microscopy and spectroscopy, higher harmonic generation, nonlinear medium

Data Fusion Methods for Nondestructive Evaluation Applications

By S. Udpa

Department of Electrical and Computer Engineering,
Iowa State University, Ames, Iowa 50011, USA

Abstract

Nondestructive testing methods involve the application of a suitable form of energy to the specimen under test. A snapshot of the material/energy interaction process is then taken via an appropriate transducer and analyzed to ascertain the state of the specimen. The nature of the energy applied to interrogate the specimen is a function of the kind of information desired from the test, the physical properties of the specimen and the prevailing test conditions. A wide variety of testing methods has, therefore, evolved in response to differing industrial needs. Each of these methods offers different 'shades' of information depending on the type of excitation energy, the manner in which it propagates through the medium, and its characteristics including amplitude, frequency, and/or wavelength. It can, therefore, be argued that a system capable of extracting complementary segments of information from data collected from multiple NDE tests can offer additional information relative to that obtained using a single NDE test. As an example, ultrasonic imaging methods offer excellent resolution and sensitivity to both surface breaking as well as subsurface cracks. The disadvantages of the method lie in its susceptibility to the effects of a wide variety of test and measurement conditions such as surface roughness and coupling. Eddy current NDE methods, in contrast, do not require contact with the test specimen. However, the technique is insensitive to defects that are embedded deep in the material and prone to variations in lift-off. The differences in the information content of the signals arise, among other factors, due to fundamental differences in the manner in which energy propagates through the test specimen. Unlike ultrasonic methods, which rely on wave propagation, the eddy current process is diffusive in nature. Each of these tests provides a perspective that is closely related to the material/energy interaction process and a synergistic concerning the state of the specimen.

A number of techniques for fusing data, both from a homogeneous as well as heterogeneous sensor environment have been proposed. This presentation will review some of the methods proposed in recent years for data fusion. The talk will focus on a few simple statistical linear and nonlinear techniques for fusing data. The advantages and disadvantages of each of these methods will be presented.

Bayesian Separation of Lamb Wave Signatures

By S.W. Kercel*, M.B. Klein, B. Pouet****

*Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, TN US 37831-6007
**Lasson Technologies, 6059 Bristol Parkway, Culver City, CA US 90230

Abstract

A persistent problem in the analysis of Lamb wave signatures in experimental data is the fact that several different modes appear simultaneously in the signal. The modes overlap in both the frequency and time domains. Attempts to separate the overlapping Lamb wave signatures by conventional signal processing methods have been unsatisfactory. This paper reports an exciting alternative to conventional methods. Severely overlapping Lamb waves are found to be readily separable by Bayesian parameter estimation. The authors have used linear-chirped Gaussian-windowed sinusoids as models of each Lamb wave mode. The separation algorithm allows each mode to be examined individually.

Keywords

Laser-based ultrasonic, weld inspection, on-line inspection, Bayesian, separation

Deconvolution of Thermography Images Obtained on Corroded Parts by Using the Thermal Modulation Transfer Function (TMTF)

By J.-C. Krapez

ONERA, DMSE, BP 72, F-92322 Châtillon-Cedex, France.
Email: krapez@onera.fr

Abstract

Thermal methods, in particular pulse thermography, suffer from thermal contrast degradation due to heat lateral diffusion. The TMTF gives a synthetic view of this phenomenon. It was built, like the MTF in visual or IR imaging, by using a target with a periodic pattern. The TMTF was numerically simulated with a model having a cluster of parallel slots on the rear side. The class of slots with small relative depth represents corrosion damage at its onset. For this class, the TMTF is expressed as a unique curve that moves with the time of observation. A Wiener inverse-filtering based on the TMTF was proposed: it clears, to some extent, the observed temperature field from the detrimental effect of lateral diffusion.

Keywords

Thermography, corrosion, deconvolution, modulation transfer function, inversion, Wiener filtering

A Multiscale Approach for Microwave Inverse Scattering Using Edge-preserving Regularization

By A. Baussard, D. Prémel

Laboratoire d'Électricité Signaux et Robotique (UPRESA CNRS 8029),
Ecole Normale Supérieure de Cachan,
61 avenue du Président Wilson, 94235 Cachan Cedex – France.

Abstract

In microwave inverse scattering, the goal is to reconstruct the permittivity profile of an object. To solve this non-linear and ill-posed problem, different algorithms exist. Usually, the iterative approaches are time consuming. A multiscale approach is proposed here in order to compute the conjugate gradient algorithm with edge-preserving regularization. The computation of the reconstruction at a coarse scale provides a low computational time. The obtained result is then used as initial guess at the finer scale. This starting solution is then closed to the attempted one which permits a lower number of iterations at the final scale.

Keywords

Microwave inverse scattering, conjugate gradient, edge-preserving, multiscale optimization

Signal Processing Techniques for the Improvement of Open-crack Detection Using a Photothermal Camera

By S. Hermossilla-Lara*, P.-Y. Joubert, D. Placko**, F. Lepoutre***, M. Piriou***

*Technical Center of Framatome – ZIP Sud 71380 Saint-Marcel – France,
**Laboratoire Electronique Signaux et Robotique (LESiR) de l'Ecole Normale Supérieure de Cachan
61 avenue du Président Wilson, 94235 Cachan – France,
***Département Mécanique du solide et de l'Endommagement (DMSE)
Office National des Etudes et de Recherches Aérospatiales (ONERA)
29 avenue de la Division Leclerc BP72, 92322 Châtillon Cedex-France.
Email : shermosilla_lara@yahoo.fr

Abstract

In this paper, the images provided by a photothermal camera (flying-spot camera) dedicated to open-crack detection are considered. A classification method is proposed and applied to the photothermal images. The method lies on a maximum likelihood diagnosis and show good performances for open-cracks detection. However, the method is limited in the case of high amplitude variations of the surface topography of the structure under test. In this case, a preprocessing of the images, based on a multi-image principal component analysis, is proposed. This method allows to significantly improve the detection of open cracks.

Keywords

Photothermal camera, flying-spot camera, infrared thermography, image processing, maximum likelihood method, principal component analysis, non-destructive testing, open-crack detection

Analysis of Pulsed Eddy Current Signals Using Time-frequency Method

By M. S. Safizadeh, B. A. Lepine, D. S. Forsyth, A. Fahr

Structures, Materials & Propulsion Laboratory, Institute for Aerospace Research,
National Research Council Canada, Building M-14, 1500 Montreal Rd., Ottawa, ON, Canada

Abstract

Detection and measurement of the material loss due to corrosion in aircraft fuselage lap splices are of great importance to life management of ageing aircraft. Pulsed eddy current (PEC) techniques have shown the potential to characterize these structures. However, variations in the probe lift-off, the interlayer gaps and material thinning produce similar response, making signal interpretation very difficult.

In this paper, time-frequency analysis methods are applied to pulsed eddy current signals with the objective of discriminating between the simultaneous occurrence of material loss and changes due to lift-off or interlayer gap. This study shows that the time-frequency analysis of PEC signals provides specific visual patterns that can be related to the interlayer gap, lift-off, and material loss.

Keywords

Pulsed eddy current, nondestructive inspection, time-frequency analysis, lap joint corrosion

Extraction of Defect Signal in Eddy Current NDE Using a DWT Based Method

By P.-Y. Joubert*, A. Baussard*, Y. Le Bihan**

*Laboratoire Electronique Signaux et Robotique (LESiR) de l'Ecole Normale Supérieure de Cachan
61 avenue du Président Wilson, 94235 Cachan – France,
**Laboratoire de Génie Electrique de Paris (LGEP),
Plateau du Moulon, 91192 Gif sur Yvette Cedex – France,
Email : pierre-yves.joubert@lesir.ens-cachan.fr

Abstract

In this paper, two defect signal extraction methods were proposed and implemented for the extraction of notch signatures in the context of eddy current testing of steam generator tubes. The methods are based on discrete wavelet transform (DWT) de-noising scheme. The first one uses a firm shrinkage of the wavelet coefficients and the second one uses a wavelet coefficient selection rule based on a multi-scale Maximum Likelihood scheme. The second method shows better extraction results since it permits to take into account the *a priori* knowledge about the defect signatures to be extracted, at each scale and across scales of the DT.

Keywords

Eddy currents, defect signature extraction, discrete wavelet transform, firm shrinkage, maximum likelihood decision

Improving the Differential Probes Detection Capability by Using Absolute Signature Estimation

By M. Bentoumi*, P. Aknin*, G. Bloch, S. Talbi*****

*INRETS, 2 avenue Malleret-Joinville, 94114 Arcueil, Cedex France.
**CRAN-ESSTIN, rue Jean Lamour 54519, Vandoeuvre-les-Nancy Cedex, France.
***RATP-ESE, 7 square F. Nadar, 94684, Vincennes Cedex, France

Abstract

Differential or double-differential probes are quite common among the many sensor technologies and allow relevant measurements in non-cooperative contexts such as modifications of target-sensor distance, variations of temperature, electromagnetic perturbations… However, the differential mode modifies the signal shape. In this paper, two inverse filtering algorithms, least squares estimation and Wiener filtering, are represented, in order to transform a differential signal into an estimated absolute one. These algorithms are then used in an eddy current application for online detection of rail defects.

Keywords

Detection, differential probe, inverse filtering, Wiener filtering, eddy currents, rail defect

Use of the Singular Value Decomposition in the Photothermal Depth Profiling

By R. Li Voti*, M.C. Larciprete*, G.L. Liakhou, S. Paoloni*, C. Sibilia*, M. Bertolotti***

*INFM and Dipartimento di Energetica, Università degli Studi di Roma "La Sapienza",
Via Scarpa 14, 00161 Roma, Italy,
Fax: +39.06.44240183, Email: Roberto.livoti@uniroma1.it
**Technical University of Moldova, Stefan Cel Mare 168, 277012 Kishinau, Moldova

Abstract

In this article, we summarize the advances obtained in the last years in the field of photothermal depth profiling. In particular we recall the physical model which well describe the heat diffusion in inhomogeneous materials, indicate the correlated inverse problems, and discuss the mathematical aspects of an inversion procedure based on the singular vale decomposition technique.

Keywords

Inverse problems, photothermal depth profiling, radiometry

Evaluation Techniques of MRTD and MRTDF in Relation to Detection Limit of Material Flaws

By A. Kamoi*, Y. Okamoto**

*Grad. School of Science and Art, University of East Asia,
2-1, Ichinomiya Gakuen-cho, Shimonoseki, Yamaguchi, Japan,
**3-7-19, Higashioshima, Hitachinaka, Ibaraki, Japan

Abstract

Infrared radiometer (IR) has been widely used in a variety of industries as one of NDT' means due to remote sensing instrumentation. The IR method is very useful for its customers to detect invisible surface and internal flaws of material. However, there are a few standards being necessary to evaluate detection limit of material flaws which should be called as minimum resolvable temperature difference of material flaw (MRTDF).

Keywords

NDT, IR, ASTM, JNDS, MRTD, MRTDF, surface flaws, internal flaws, detection limit

A Generalized Approach to Signal Processing for Active Thermography

By S.M. Shepard, J.R. Lhota, T. Ahmed, B.A. Rubadeux

Thermal Wave Imaging, Inc., 835 Livernois, Ferndale, MI 48220,
Email: sshepard@thermalwave.com

Abstract

Although active thermography has proved to be an effective NDE tool for numerous in-service and manufacturing applications, it is subject to inherent limitations because of its diffusive nature. Despite these limitations, the signals obtained from active thermographic methods are highly deterministic, in the sense that they are always monotonically decreasing. We have used this fact to great advantage in treating the post-excitation time evolution of each pixel, and have been successful in dramatically reducing temporal and spatial noise in the resultant image, and minimizing blurring that occurs as a result of thermal diffusion. We have applied this approach to data acquired using various excitation sources (E.g. pulsed or scanned optical, high power ultrasound) and used the processed data to create extremely low-noise images using the pulsed phase technique. In addition to significant signal to noise improvement, our approach allows data reduction by an order of magnitude, so that large structures (e.g. aircraft control surfaces) can be inspected as a single data set, rather than an array of individual files that must be analyzed separately. Examples using pulsed and scanned excitation on aerospace an turbine engine components will be represented.

Keywords

Infrared thermography, nondestructive testing, signal processing

Characterization of a Moving Surface Roughness by Backscatterer Ultrasound Performed with Time-frequency Analysis and High Order Statistics

By S. Dos Santos, P. Maréchal, J.-M. Girault, F. Vander-Meulen

Laboratoire UltraSons Signaux et Instrumentation de l'Université François Rabelais-GIP UltraSons, EIVL Rue de la Chocolaterie, BP3410, 41034 Blois Cedex, France

Abstract

The determination of a calibrated surface roughness with translation velocity of v=15 ms^{-1} was investigated with ultrasonic backscattered technique based on Doppler effect. The difficulty of the Fourier analysis to detect with accuracy the instantaneous changes of roughness induces a time-frequency analysis. The need to analyze both frequency and temporal nature of data is due to the non stationarity of measured signals. The theoretical study demonstrates that the Doppler spectrum is the product of the spatial spectrum of the surface roughness and the velocity of the surface. An accurate detection of roughness has been derived thanks to the spectrogram representation.

Keywords

Backscattering, ultrasonic imaging, roughness surface, time-frequency analysis

Optimal Design of Radioactive Particle Tracking Experiments for Flow Mapping in Opaque Multiphase Rectors

By S. Roy*, F. Larachi, M.H. Al-Dahhab*, M.P. Dudukovkiae***

*Department of Chemical Engineering, Campus box 1198,
Washington University, One Brookings Drive, St. Louis, MO 63130, USA
**Department of Chemical Engineering, Université Laval,
Québec, Sainte-Foy, Canada, G1K 7P4

Abstract

In the past decade, radioactive particle tracking techniques have emerged in the field of chemical engineering and have become increasingly popular for non-invasive flow mapping of the hydrodynamics in multiphase reactors. Based on –ray sensitization of an array of scintillation detectors, the computer automated radioactive particle tracking (CARPT) technique measures flow fields by monitoring the actual motion path of a single discrete radioactive flow follower which has the physical properties of the phase whose motion is being followed. Limitation to the accuracy of CARPT lies in the error associated with the reconstruction of the tracer particle position which affects the space-resolution capability of the technique. It is of interest, therefore, to minimize this error by choosing wisely the best hardware and an optimal configuration of CARPT detectors' array. Such choices are currently based on experience, without firm scientific basis.

In this paper, through theoretical modeling and simulation, we described how the accuracy of a radioactive particle tracking setup may be assessed a *priorh.* Through an example of a proposed implementation of CARPT on a gas-solids riser, we demonstrate how this knowledge can be used for choosing the hardware required for the experiment. Finally, we show how the optimal arrangement of detectors can be effected for maximum accuracy for a given amount of monetary investment for experiment.

First Article Inspection Based on Industrial X-Ray Computed Tomography

By Th. Lüthi*, A. Flisch*, J. Hofmann*, A. Obrist*, J. Wirth**

*Swiss Federal Laboratories for Materials Testing and Research (EMPA),
Electronics/Metrology Section, CH-8600 Dübendorf, Switzerland
**Basel Institute of Technology (FHBB), CIM-Centre, CH-4132 Muttenz, Switzerland

Abstract

Up to now, a large amount of computed tomography applications was in the field of flaw detection, failure analysis, dimensional measurements of geometrical features or statistical investigations of material properties. Recent developments in the hardware design and the computational possibilities lead more and more to three-dimensional computed tomography, either directly by using a two-dimensional detector or indirectly by stacking together single slices. One of the reasons to do so is investigation of inner surfaces to measure dimensions.

The main application of such a technology is the first article inspection of cast components by comparing point cloud data with the CAD model. Deviations can be shown as colour mps on three-dimensional views or slices in any required orientation.

Keywords

Light metal castings, point cloud, surface segmentation, three-dimensional image processing

Geometric Factors Influencing Signal Attenuation in Ultrasonic Spot Weld Testing

By D.R. Roberts*, W. Waddell*, J. Mason**

*Welsh Technology Centre, Corus, Port Talbot, UK.
**EE Dept., U.W. Swansea, Swansea, UK.

Abstract

Most published papers on ultrasonic spot weld testing report that signal attenuation may be used to estimate weld size. It has been generally believed that the grain structure of the welded steel significantly increases ultrasound scattering, leading to higher attenuation in large welds. However, in recently published work we present experimental evidence to suggest that attenuation is not caused by weld gain structure. Results suggest that the geometry of the weld surface can cause the observed attenuation characteristics.

Keywords

Ultrasound, spot welds, attenuation, scattering, non-destructive testing

Pulsed Photothermal Radiometry for Plastic Qualification Regarding Laser Beam Weldability

By H. Haferkamp, A. von Busse, M. Goede, M. Hustedt

Laser Zentrum Hannover e.V., 30419 Hannover, Germany

Abstract

The laser beam welding process of polymers strongly depends on the optical and thermographysical properties of the plastic material which can be adapted using corresponding filling materials and pigments. So far, material's qualification related to their laser beam weldability has been carried out by extended experimental welding investigations. LZH has developed a thermographic system for a fast and non-destructive evaluation of material's properties regarding laser beam weldability. The plastic samples are heated with a short laser pulse, and the temperature development on the top and on the bottom side of the sample is observed simultaneously by an IR-camera.

Keywords

PPTR, thermography, plastic laser beam welding, plastic weldability, materials qualification

A MAP-EM Half-quadratic Regularization for Quantitative ECT and TCT on Nuclear Wastes

By R. Thierry, J-L Pettier

Commissariat à l'Energie Atomique (CEA) de Cadarache,
DED/SCCD/LDMN: Laboratoire de Développement de Mesures Nucléaires,
13108 St-Paul Lez Durance, France

Abstract

An evaluation method to quantify the γ-activity distribution of radionuclides emitting in the (59.5 keV, 1.4 MeV) energy range contained in 220-litre nuclear waste drums has been investigated. Emission Computed Tomography (ECT) coupled with Transmission Computed Tomography (TCT) is employed hen further characterization of drums are needed, especially when assumption over homogeneous distribution of density and activity aren't fulfilled. The emission measurements are often limited in number – because of the time-demanding acquisition procedure and the poor efficiency of the HpGe detector – and affected by serious attenuation factors, especially for low-energy emitters. Hence we propose a bayesian regularization using the *Maximum A Posteriori* (MAP) estimator, with a poissonian likelihood. The potential function of the gibbsian distribution is chosen convex, and its characteristics authorize the preservation of the natural image discontinuities. The optimum of the general nonlinear function is finally reached with a half-Quadratic (HQ) minimization. The so called MAP-EM-HQ algorithm is compared with its gaussian-like equivalent. The MAP-CG-HQ and with more classical Maximum Likelihood ML-EM and Conjugate Gradient (CG) algorithms. The analysis of the results over simulated measurements, and real data showed an improved performance compared to other methods, both in quantification and in localization of radio-elements. The study underline the impact of naturally positive constraint inherent to the MAP-EM-HQ over the reconstructed images. Further work has to be done in order to specify an optimal selection of Gibbs hyperparameters and an appropriate acceleration of the convergence.

Keywords

Quantification, emission tomography, maximum a posterior, nuclear waste drum, half-quadratic regularization, markov random field

Photothermal Steel Hardness Measurements Influence of Surface Roughness

By H.G. Walther[1], D. Fournier[2], J.C. Krapez[3], M. Luukkala[4], B. Schmitz[5], C. Sibilia[6], H. Stamm[7], J. Thoen[8]

1-Institut fuer Optik und Quantenelectronik, Max-Wien-Platz 1, 07743 Jena, Germany
2-ESPCI Paris, France,
3-ONERA Paris, France,
4-University Helsinki, Finland,
5-ILM Ulm, Germany,
6-University di Roma "La Sapienza", Roma, Italy,
7-JRC Ispra, Italy,
8-University Leuven, Belgium

Abstract

Within a European Thematic Network project the feasibility of photothermal steel hardness measurement was studied. The correlation between mechanical hardness and thermal conductivity was found out by studying the steel microstructure and establishing of calibration curves. Novel inversion techniques as neural networks and Maximum Entropy Method have been applied for depth profile retrieval. The appropriate measuring conditions for photothermal hardness profile estimation have been defined. Because the influence of surface roughness on photothermal data cannot be ignored the roughness effect was studied with respect of thermal wave propagation and signal generation.

Keywords

Radiometry, thermal wave, application, depth profile, inversion, roughness, hardness

Transient Thermography Simulation by SPICE

By S. Tuli, R. Gupta

Center for Applied Research in Electronics, Indian Institute of Technology Delhi,
Hauz Khas, New Delhi, India

Abstract

This paper presents a new and simple technique for transient thermography simulations for nondestructive evaluation, using a popular an freely available circuit simulator SPICE (Simulation Program with Integrated Circuit Emphasis). Given a sample having surface and/or subsurface defect(s), a resistance-capacitance network approach is used for the modeling of heat conduction in it. SPICE simulation then predicts the temperature, as a function of time, on the surface and at various depths inside the sample. Experimental corroboration of predicted temperature contrast of the surface, as a function of time, is reported.

Keywords

Transient thermography, simulation, modeling, SPICE, RC network

Homogeneity Testing Analysis by Application of Energy and Entropy Balance

By M. Beihaqi, S. Belattar, A. Obbadi, S. Sahnoun

Laboratoire d'Energétique et de Traitement du signal,
U.F.R. Instrumentation et Traitement du sigal,
Faculté des sciences - ElJadida

Abstract

The thermal non-destructive testing allows to diagnose the homogeneity of a material without damaging its structure. The objective of this article is to show that the energy and entropy balances can be used as a tool for the analysis of the non-destructive thermal control. On the assumption of a one-dimensional thermal conduction, a calculation based on the finite differences method was carried out for analyzing heat flow and entropy rate. It seems that a defect more (or less) effusive than the inspected material is relatively easier to detect than a defect more (or less) diffuive.

Keywords

NDT, homogeneity, diffusivity, effusivity

Wood Inspection by Infrared Thermography

By A. Wyckhuyse, X. Maldague

Electrical and Computing Engineering Department,
Université Laval – Quebec City (Quebec), Canada G1K 7P4,
Ph: (418) 656-2962, Fax: (418) 656-3594, Email: maldagx@gel.ulaval.ca

Abstract

Wood is used everywhere and for everything. With times, this material presents many adulterations, which degrade his physical properties. This work present a study of infrared thermography NDT for wood decay detection. The study is based on the difference of moisture content between sound wood and decay. In the first part, moisture content influence on response signal is determine. The second part define the limits of infrared thermography for wood decay detection. Results show that this method could be used, but with many cautions on depth and size of wood defects.

Keywords

Wood inspection, infrared thermography, non-destructing testing

Imaging of Multi-layered Conductive Components with Pulsed Eddy Currents

By Y.A. Plotnikiv, S.C. Nath, C.W. Rose

General Electric Corporate Research and Development,
1 Research Circle, Niskayuna, NY 12309-1135

Abstract

Pulsed Eddy Current (PEC) method has been demonstrated to be an effective technique for deep penetration of conductive materials. Two-dimensional scanning of multi-layered structures such as aircraft skin structures with a PEC probe provides detection of subsurface defects. In the present work, diffusion of an electromagnetic wave is used for “in-depth slicing” of aluminum structures. Images of artificial flaws in a multi-layer specimen are formed by time gating the sensor coil signal at each point of a two dimensional scan. It is demonstrated that an image of a particular layer or a combined image of the whole multi-layer structure can be obtained by adjusting the time interval used for data processing.

After flaw detection, size a severity of the defect can be estimated. A problem of accurate reconstruction of the internal geometry of the component under test is considered. Experiments were performed on a specimen comprising four aluminum panels, each 1.6 mm thick. One panel has a series of 8 flat bottom blind holes (FBH), 6 and 19 mm in diameter that simulate material loss from ranging from 6 to 31%. An image processing routine is applied to reconstruct geometry of the component from a series of eddy current images obtained with a two-dimensional scanner. The steepest points of the profiles can bu used for detect size determination. Profiles for deeply buried defects are extracted from the phase images that were obtained using the Discrete Fourier Transform. The advantages and limitations of the technique are discussed.

Keywords

Pulsed eddy current, corrosion, assessment, defect size estimation

Detection of Inclusions in Steel Slabs Using Laser-ultrasonic SAFT Imaging

By D. Lévesque, B. Champagne, A. Blouin, J.-P. Monchalin

Industrial Materials Institute, National Research Council of Canada,
Boucherville, Québec, J4B 6Y4, Canada

Abstract

Method is presented for detecting small defects located below the surface of cast slabs. The technique combine laser-ultrasonics and synthetic aperture data processing for inspection on descaled slabs. An improved synthetic aperture data processing (F-SAFT) performed in Fourier domain which includes the control of the aperture as well as spatial interpolation is used. A further improvement in F-SAFT reconstruction is made by taking into account the inspected surface profile, simultaneously measured by an optical surface profiler. Samples with wavy inspected surface and flat-bottom holes at different depths are tested to validate the correction method for surface profile. Industrials steel slab samples are then tested to confirm the reliability of the proposed laser-ultrasonic approach. The inspection time duration and the resolution limit are also discussed.

Keywords

Laser-ultrasonics, SAFT imaging, flaw detection, steel slab

Crack Detection and Imaging Using Ultrasonic Guided Waves and EMATs

By A. Chahbaz*, A. Cyr*, R. Sicard, J. Goyette**, J. Zellouf****

*Tektrend International, NDT Technology Development Group,
2001 A St. Regis Blvd., Montreal, Que., H9B 2M9,
**Institut de Recherche sur l'Hydrogène, Université du Québec à Trois-Rivières,
C.P. 500, Trois-Rivières, Québec, Canada, G9A 5H7

Abstract

Ultrasonic guided waves demonstrate potential as promising, global and fast inspection methods. They can be used to complement, and, in some cases, be an alternative to conventional ultrasonic C-scan inspection methods. Moreover, due to the multi-mode character of guided waves, a selection of modes can be optimized for the detection of particular defects. Mode optimization can be done by selecting modes with maximum group velocities (minimum dispersion) or by analysis a wave mode structures (particle displacements, stresses and power distributions).

In this work, we use guided modes for long-range defect detection and for evaluation of the integrity of bonded structures. We experimentally investigate and demonstrate the ability of guided waves using Electromagnetic Acoustic Transducers (EMATs) to detect corrosion in single and layered structures. Suitable EMAT probes with optimized wavelength are designed and tuned. For each guided wave test, a single line of data is collected by moving the EMAT probe along the inspected specimen. Signals are then presented in color-coded two-dimensional B-scan format for ease of interpretation. For defect separation and characterization, the images are the averaged and reconstructed using a suitable artificial focusing technique.

Keywords

Corrosion, ultrasonics, Lamb waves, EMATs, adhesive joints inspection

Measurement of Temperature Distributions of Liquid Packing Bags Made of Plastic Films during Heat Sealing Using Infrared Thermography

By E. Umezaki, H. Yamaguchi

Dept. of Mechanical Engineering, Nippon Institute of Technology,
4-1 Gakuendai, Miyashiro, Saitama 345-8501, Japan

Abstract

The temperature on the surface of a heat-sealed area in liquid packing bags made of laminated plastic films was measured by an infrared thermography technique to investigate the effects of temperatures of heat-sealing plates and rates of film feed on the quality of heat seal of the films in the heat-sealed area, the quality of which is evaluated on the basis of whether separation between heat-sealed films exists. The results revealed that the distributions of temperature on the surfaces of the heat-sealed areas could be used to evaluate the heat-seal quality.

Keywords

Infrared thermography, liquid packing bag, plastic film, heat sealing, heat-seal quality

Transfer Function Method for Thermal Diffusivity Measurement by IR Thermography

By S. Marinetti*, P.G. Bison*, E. Grinzato*, C. Bressan*, A. Mazzoldi**

*CNR – ITEF, C.so Stati Uniti, 4 – 35127 Padova, Italy
**CNR – ISDGM, S. Polo, 1364 – 30125 Venezia, Italy

Abstract

IR thermography is becoming a more and more powerful tool for fast and reliable thermal diffusivity measurements. Nonlinear least squares fitting routines have been widely used to reduce temperature data to diffusivity values. This technique works very well under less restrictive conditions than those required by the Parker's method. Nevertheless matching the analytical model with the actual experimental procedure is not always an easy task. In this paper the effects of mismatched heating functions on the final diffusivity value are reported. The use of time deconvolution is then proposed as a pre-processing tool in order to make the measurement independent of the heating function. Results of numerical simulations and experimental tests are presented.

Keywords

Infrared thermography, thermal diffusivity, nonlinear best fit, deconvolution

Reconstruction of Thermal Diffusivity Distribution at a Microscopic Scale from Modulated Photothermal Experiment

By J. Jumel*, N. Terrien*, O. Arnould****, J.C. Krapez*, F. Lepoutre***

*DMSE/MECS, ONERA, 92322 Châtillon France,
**CEA, Le Ripault, 37260, Monts, France,
***DGM, ENS-Cachan, 94235, Cachan, France,
****LMT-Cachan, 94235, Cachan, France

Abstract

This paper deals with the inversion of modulated photothermal experimental data I functionally graded materials (FGM) whose thermal properties are continuously varying parallel to the sample surface. Simple relations are proposed, to interpret quantitatively the measurement performed either in temperature cartography or imaging mode. At first, we present the code we implemented to calculate the periodic temperature increase produced during photoreflectance experiment is presented. Then we propose two inversion procedures that are validated on a simulated set of thermal parameters reproducing the expected thermal properties distribution in a Copper/nickel assembly with diffusion profile.

Keywords

Modulated photothermal methods, functionally graded material, diffusion, thermal diffusivity measurement

NDE based on the Analysis of Ultrasonic Waves Nonlinear Interaction in Inhomogeneously Predeformed Material

By A. Ravasoo

Department of Mechanics and Applied Mathematics,
Institute of Cybernetics at Tallinn Technical University,
Akadeemia tee 21, 12618 Tallin, Estonia

Abstract

Simultaneous propagation of two longitudinal waves in homogeneously predeformed nonlinear elastic material is considered theoretically. An analytical solution that describes evolution of wave profiles during propagation, reflection and interaction in the sample of material undergoing plain prestrain is derived. Evolution of nonlinear effects of sine wave propagation on the surfaces of the material is studied in more detail. Amplification of nonlinear effects in wave interaction interval is observed. Essential is that predeformation brings on modulation of these effects. Analysis of the character of nonlinear effects modulation enables to solve some NDE problems for inhomogeneously predeformed materials.

Keywords

Nonlinear wave interaction, nonlinear elasticity, inhomogeneous predeformation, NDE

Residual Methanol Efficient Burned as a Substitute of Intermediate Fuel Oils

By V.V. Ghia

Institute for Thermal Engines, 246 Pacii Blvd., Sect 6, Romania
Email: aners@nare.renerg.pub.ro, Fax: (00-40.1) 220.13.26

Abstract

In the first part, a combustion testing method using a simulator for determining the combustion-ignition characteristics (CIC) of liquid fuel droplet (LF), applied to liquid combustible waste (CW), is preconized. The second part presents the preliminary results concerning the droplet combustion of residual methanol (RM), phenol residue (PR) and different LF. In the third part, a method for useful heat transfer (UHT) comparison with application at the combustion of RM replacing the intermediate fuel oil (IFO) for a technologic steam boiler is proposed. Thus the RM in comparison with the IFO decreases the radiant emissions and the temperature of flame. For obtaining the same total UHT at the nominal operation regime of boiler, it is necessary to increase the convection UHT. A new type of burner for RM combustion heaving fully automatic operation was conceived and presented in an industrial application, especially as a low NO_x combustion system.

Keywords

Methanol, combustion, research, development, NO_x reduction, energy recovery, burner, boiler, light near-infrared radiation

Nondestructive Evaluation of the Stability Threshold of Geomaterials

By M.P. Luong

Laboratoire de Mécanique des Solides, CNRS UMR 7649,
Ecole Polytechnique, 91128 Palaiseau Cedex France

Abstract

A nondestructive testing technique is used to detect the occurrence of material instability subsequently causing to detect the instability limit, thus providing a very useful early warning for the security of underground work at high risk for environment. An input-output non-parametric based on ultrasonic pulse propagation and a nonlinear analyzer for data reduction procedure were chosen to portray the nonlinear behavior of a deep argillaceous rock subjected to increasing static shear loads. Based on multidimensional Fourier transform, the nonlinear analyzer permits to separate linear and nonlinear parts. It reveals to be very useful for a highly sensitive detection of the material instability threshold beyond which the microcracking process occurs and subsequently leads to a propagating damage.

Keywords

Geomaterials, nondestructive evaluation, nonlinearity ratio, ultrasonic testing, Volterra expansion

Two-dimensional Analysis of Thermal NDT by the Numerical Method of Control Volumes

By A. Obbadi, S. Belattar, M. Beihaqi, A. Tmiri, A. Ballouti

Laboratoire d'Energétique et de Traitement du signal,
U.F.R. Instrumentation et Traitement du signal,
Faculté des sciences - ElJadida

Abstract

The present paper is devoted to investigate the possibility of obtaining the description of internal defect structure by use of steady isothermal lines. To estimate capabilities of the thermal method for quantitative characterization of inclusions, a numerical model of the two-dimensional heat transfer problem based on application of control volume method, has been used. The results were analyzed taking into account the main influenced parameters such as: the physical nature of the defect and its inclination within the structure.

Keywords

Steady heat transfer, isothermal lines, internal defect, thermal control

Raw Materials Production and Advances in Rocks NDE

By V.D. Vladimirov

Dept. of Mineralogy, Petrology & Economic Geology, Sofia University,
St. Kl. Ohridski, 15 Tzar Osvoboditel, Sofia, 1000, Bulgaria

Abstract

It is an analysis of the relative importance of metallic and industrial minerals and the role of nondestructive methods is discussed. The authors aim is on the basis of widespread nondestructive rocks evaluation to create rock physical properties data base, for the needs of: construction activity, industry, geological genetically reconstructions, natural and technogenic hazard assessments, nuclear and high toxic waste disposition, environment protection and many others.

Keywords

Rocks, nondestructive, industrial minerals, raw materials, economics

Determination of Depth and Fracture Size in a Sample Case of One Broken Prestressed Tendon by Magnetoscopy

By M. Klein*, B. de Halleux, X. Maldague***

*Computer Vision and System Laboratory, Université Laval,
Ste-Foy, G1K 7P4, Québec, Canada
**Mechanical Engineering, Université de Louvain,
B1348 Louvain-la-Neuve, Belgique

Abstract

It has been shown how to magnetoscopy can be used to detect a fracture in a steel bar or a simple case of prestressed tendon in a concrete structure by extracting the magnetic signature. The signature is a function of many parameters (depth of the bar, size of the break, diameter of the bar, thickness of the steel sheaths if any and so on). We propose a method to lookup 2 parameters among them for a simple axisymmetric shape. The method can be extended to determine a maximum of 3 parameters.

Keywords

Magnetoscopy, concrete structure, bar, steel, fracture, non destructive testing, prestressed concrete, tendons, wire strand, lookup table, surface fitting