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Session: Modeling Applications

Aspects of Inspection Qualification for CANDU Piping Welds

Peter CIORAU*, Trek HAZELTON, Jessica LAM, Vajira JAYASINGHE, Lou PULLIA, Jason COULAS,
*Ontario Power Generation Inc., L1V 2R5 Pickering, Canada
e-mail: peter_ciorau@rogers.com, phone: +

Abstract:
The paper presents technical aspects of inspection qualification for ultrasonic in-service inspection of CANDU piping ferritic welds with outside diameter range between 172 mm to 660 mm and thickness range between 9mm to 80 mm. The OPG contribution to inspection specification is discussed and illustrated. Validation through the ENIQ concept of technical justification are presented for different aspects of UT conventional procedure; including crack skew/tilt issues, sensitivity setting, equipment substitution and technique development. ESBeam Tools was used to assess the coverage zone (inspection plan). Mock-up design and specific results are also presented. OPG has one of the most diverse sets of mockups for ferritic piping welds in the world (32 mock-ups grouped in 7 families with 200+ implanted flaws) as well as 15 bars with fatigue cracks (thickness 9 mm – 47 mm; crack height: 2.5 mm – 19 mm). Examples of UT amplitude response on different flaws for 20” sch 100 mock-up family are presented in the paper. The PAUT sizing procedure was developed in parallel with the UT conventional procedure qualification; following the same CIQB process. The following aspects are presented: technique selection, probe selection, ligament assessment, weld defect pattern display, sizing capability assessment, possibility and limitations of single-index semi-automatic scanning, short-comings of one-side PAUT examination, and tolerances on essential parameters. Flaw sizing methods based on ACG/TCG and noise-plus techniques are also presented and commented. The PAUT sizing procedure in both manual and semi-automatic modes is ready for the qualification process, based on experimental evidence from mock-ups and field data on economizer welds, on CIVA simulation and inspection plan coverage using ESBeam Tools,. Technican training aspects are also presented and commented on.

Keywords:

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Simulation of Time-of-Flight Diffraction (ToFD) Technique by Finite Element Method

Farhang HONARVAR*, Somayeh KHORASANI,
*Mech and Indust Engrg, University of Toronto, M5S 3G8 Toronto, Canada
e-mail: honarvar@mie.utoronto.ca, phone: 416-978-1271, fax: 416-978-7753

Abstract:
Time-of-flight Diffraction (ToFD) is an ultrasonic nondestructive testing technique used for detection, sizing and evaluation of discontinuities. The ToFD technique, which is based on the diffraction phenomenon, is usually applied to thick sections (> 15 mm). In this paper, we use the Finite Element Method (FEM) for modelling the ToFD technique in a two-dimensional geometry. Ultrasonic waves are generated in samples with different types of notches and the interaction of waves with these notches is monitored. This study does not only provide a better understanding of the diffraction phenomenon but can also help in design and implementation of new test procedures for examination of industrial parts. One major application would be using the ToFD technique for testing thin sections in pressure vessels and pipes.

Keywords:

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Software Tools for the Design of Phased Array UT Inspection Techniques

Daniel RICHARD*, David REILLY, Johan BERLANGER, Guy MAES,
*Zetec, G1N 2C9 Québec, Canada
e-mail: DRichard@zetec.com, phone: +1 (418) 263-3693, fax: +1 (418) 263-3742

Abstract:
Software modeling tools are required for the design and validation of both conventional UT and phased array UT inspections. However, they are perhaps more essential for inspections involving phased arrays as these are generally applied on complex geometries and can involve multiple beams generated from a single probe: for example, the increasing application of 2D arrays that can generate beams with a range of refraction and skew angles. Two modeling tools that are commonly used are ray tracing and beam simulation. 3D ray tracing can be utilized, for a given component and defect combination, to determine where a probe should be placed and what refraction and skew angles are required to insonify the defect. Beam simulation can be utilized to design probes to meet a specification. Alternatively, it could be used to assess whether or not an available probe will be suitable for a particular application. The paper will give a description of features of the 3D Ray Tracing and Beam Simulation tools available in Zetec's UltraVision® 3 software.

Keywords: Ultrasonic Testing (UT), Modeling and Simulation, Phased Array

2010-09-01 00:00 Room: Forum Room: Special Sessions
Session: Modeling Applications

Importance of simulations for Nuclear and Aeronautical inspections with Ultrasonic and Eddy Current Testing

Esmeralda CUEVAS*, Andrés GARCIA, Francisco J. FERNANDEZ, Jose R. GADEA, Javier CORDON,
*NDE Innovation, Technological Development Direction, TECNATOM, 28703 San Sebastián de los Reyes, Spain
e-mail: ecuevas@tecnatom.es, phone: +34 91 659 86 00 EXT: 8230, fax: +34 91 659 8677

Abstract:
Nowadays the industry is not only demanding quality and accuracy in the global process of the NDE inspections, but also saving time and money. When a new inspection is going to be developed, after knowing the characteristics of the component to be inspected (material and geometry) and the postulated defects (location and dimensions), one of the first steps is to specify the probes. When mock-ups with realistic defects are available, different probes can be tested to define finally the set of final probes. This process is not always completely efficient. Sometimes it is not possible to have mock-ups for all the types, dimensions and positions of the postulated defects. Selecting the more suitable probe could require testing a lot of probes, which is expensive and time consuming. Sometimes, it is also difficult to analyse the impact of the geometry in the detection and sizing of defects, and to assess the influence of parameters such as the dimensions, location, skew and tilt of the defects, or the limited access of the beam to the inspection volume. These preliminary to the inspection preparations are increased when phased arrays probes are used, because new parameters like focal laws, orientations and focalizations of the beams should be taken into account. Simulation is a powerful tool to complement the results obtained on mock-ups. It can help to select and verify different probes and to define the characteristics of the defects that could be included in the mock-ups. When simulation is used properly, the process of preparing NDE inspections is less expensive and time consuming. This paper describes some examples about how simulation has been used in different applications on nuclear and aeronautical inspections.

Keywords: NDT-wide, Electromagnetic Testing (ET), Ultrasonic Testing (UT), Modeling and Simulation, radii, aeronautical, nuclear, composite

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Session: Modeling Applications

Automated Ultrasonic Inspection of Nozzle Welds using Phased-Array Ultrasonic Testing - Part 1 - Inside Access

Robert K. GINZEL, Ed GINZEL*,
*Materials Research Institute, N2J 4G8 Waterloo, Canada
e-mail: eginzel@mri.co.ca, phone: +519-886-5071, fax: +519-886-8363

Abstract:
Nozzle weld inspections have long been an important function carried out by ultrasonic test methods. When performed using manual techniques the plotting of defects located is a time-consuming ordeal requiring local profiles, wall thickness readings and compensation for curvature effects. The introduction of Code Case 2235 for ASME compliant vessels has allowed many welds in the vessel be inspected using ultrasonic methods. The computerisation requirement in the Code Case is easily applied to longitudinal and circumferential butt welds. However, complexities of geometry can limit the useful application of ultrasonic methods to nozzle welds unless provision is made for the mechanics to provide adequate tracking to assure full-volume beam coverage. This paper discusses the options available when phased-array techniques are used with mechanical apparatus that provides encoded motion from the inside surfaces of either the nozzle or the vessel. Modelling provides evidence of the physical parameters that must be considered for full coverage. Actual scan results are provided to indicate how well the models predict the coverage by detecting targets at the edges of the weld zones. Modelled and actual results indicate that a scan-plan made using a ray-tracing programme can provide suitable indication of required coverage. In many cases, the mechanical apparatus used to guide the probe can be designed with a minimum of complexity when scanning access is from the inside surface of either the nozzle or vessel.

Keywords: Ultrasonic Testing (UT), Phased-array, mechanised, nozzles

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Automated Ultrasonic Inspection of Nozzle Welds using Phased-Array Ultrasonic Testing - Part 2 - Outside Access

Robert K. GINZEL, Ed GINZEL*,
*Materials Research Institute, N2J 4G8 Waterloo, Canada
e-mail: eginzel@mri.co.ca, phone: +519-886-5071, fax: +519-886-8363

Abstract:
Part 1 of this series of papers on nozzle weld inspections by phased-array ultrasound options, provided several recommendations for scanning from the nozzle or vessel inner surfaces. Part 2 discusses scanning when access is available from the outer surfaces of the nozzle or vessel. Modelling provides evidence of the physical parameters that must be considered for full coverage. Actual scan results are provided to indicate how well the models predict the coverage by detecting targets at the edges of the weld zones. Modelled and actual results indicate that a scan-plan made using a ray-tracing programme can provide suitable indication of required coverage. In many cases, the mechanical apparatus used to guide the probe can be designed with a minimum of complexity when scanning access is from the outside surface of either the nozzle or vessel.

Keywords: Ultrasonic Testing (UT), mechanised, Phased-array, nozzles

2010-09-01 00:00 Room: Forum Room: Special Sessions
Session: Modeling Theory and Simulations

VVER RPV UT Results Modeling with “CIVA” Software Application

Igor KADENKO, Ruslan IERMOLENKO, Artem KADENKO*, Nadiia SAKHNO,
*Nuclear physics department, Taras Shevchenko National University of Kyiv, 01030 Kyiv, Ukraine
e-mail: kadenkoartem@gmail.com, phone: (044)5213216, fax: (044)5213216

Abstract:
In accordance with the requirements of [1-2], the in-service inspection (ISI) systems used at nuclear power plants must be qualified. The development of technical justification (TJ) for in-service inspection system is one of the most important stages in the qualification process. Base on [3] the TJ can be based on practical and theoretical results. In the TJ it is supposed to use the mathematical models and software, which allows to simulate the results of real NDE. Application of simulations for TJ has several advantages, namely: the possibility of key parameters and key variables variation, NDE ISI system sensitivity assessment for various real cases, the ability to optimize the required number of test samples, etc. In this paper we present the results of modelling of reactor vessel VVER-1000 ultrasonic testing using software «CIVA». Computer models for the cylindrical part for the reactor pressure vessel, for the transition radii zones and cylindrical part of the nozzle DU-850 were developed. In these reactor pressure vessel the following expected or similar to operational defects have been introduced: the semi-elliptic cracks, the flat-bottomed holes and the notches. Computer models of the phased array ultrasonic transducers: 2.25MHz-5x6 elts, 1.5MHz-30 elts and 2.25MHz 2x16 elts were constructed. Dependence of amplitude changing of ultrasonic signal reflected on cracks depth (ligament) is studied and presented. This dependence was obtained for a case of overlapping and shifting of centers of defect itself and transducer. Application of these results in practice enebles NDE personnel to assess the sensitivity of defects detection. References: 1. NP 306.2.113-2005 “Requirements for Qualification Performance of NDT ISI Systems for NPP equipment and pipes”; 2. European methodology for qualification of non-destructive tests (third issue)// EUR 22906 EN// ENIQ Report nr. 31 – 2007; 3. ENIQ RECOMMENDED PRACTICE 2: RECOMMENDED CONTENTS FOR A TECHNICAL JUSTIFICATION (issue 1)// EUR 18099 EN// ENIQ Report nr. 4 – 1998.

Keywords: Ultrasonic Testing (UT), Modeling and Simulation, simple slanted transducers, phased array ultrasonic transducers

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Session: Modeling Applications

Microhardness Vickers and Sound Velocity in Titanium Oxide

Maria A. CARAVACA*, Ricardo A. CASALI, Julio C. MIñO, Luis E. KOSTESKI, Ricardo J. L. BARRIOS DAMBRA,
*Facultad de Ingenieria, Universidad Nacional del Nordeste, 3500 Resistencia, Argentina
e-mail: mac@ing.unne.edu.ar, phone: 54-3722-420076 (145), fax: 54-3722-428106

Abstract:
The microhardness of orthotropic TiO_2 was calculated from Voigt-Reuss-Hill (VRH) approximation, a useful scheme by which one calculates isotropic polycrystalline elastic moduli in terms of the anisotropic single-crystal elastic constants. These are obtained with first principles calculation and are used to parameterize the Discrete Elements Method (DEM) for brittle materials. Our results implicate a more important fact that the prediction of hardness of a material using a simple empirical relation proposed by Teter et al based on its bulk modulus or shear modulus. Because hard materials have many superior properties of higher compression strength, thermal conductivity, beside higher hardness, this work has been devoted to obtain theoretically the elastic properties in crystal single and derivative properties like longitudinal and transversal sound velocities used in nondestructive test. In the DEM the indentation process consist of two steps: loading (applying maximum load for a few seconds) and unloading. After this process, the permanent impression left by the indentator is measured. As it can be seen in the work by Niezgoda et al. the material is considered to suffer a breakage, and not an elastic deformation, thus the shape is not restored after the load is removed. Following this concept, DEM considers that the load produces breakage on the material under the indentator and that the impression left is permanent. The calculated Vickers microhardness value in the polycrystalline approach is in the range of 28 to 32 GPa, close to the lower experimental value obtained at normal pressure in the quenched sample at 77 Kelvin.

Keywords: Modeling and Simulation, Hardness Testing

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Brick masonry elastic modulus determination using the numerical simulation and experiments of sonic wave propagation.

Jose Vicente FUENTE*,
*Technological Unit of Research for Safety & construction technology, AIDICO, 46980 Paterna, Spain
e-mail: jvfuente@aidico.es, phone: +34961318278, fax: +34961318033

Abstract:
The aim of this work is to characterise the brick masonry reproductions using nondestructive monitoring testing during the load compression tests. They were fabricated two walls using handicraft solid brick and limestone mortars with low mechanical performance to simulate the typical historical elements regarding their mechanical behaviour. The load process has been stated on 10 Tones until 60 Tones using a 10 Tones stepping. The walls are 300 x 224 x 22 cm of size one with artificial defects and the other without them. The defects were the brick absence or breaks, no mortar joints in specific zones. Using mechanical wave propagation, it is carried out some test during a load stepping process to analyse how evolves the observed parameters and the dependence of the stress status. The experimental tests consist of the application of the multichannel sonic test to get the velocities and elastic modulus of the structure, and after that it will compare with the numerical simulations of single component, bi-component (brick & mortar) and 3D. From the observation has been found the influence of defects, the mortar and bricks to assign the final wall properties and it will discuss the scope and feasibility of techniques usage.

Keywords: Rayleigh, sonic test, wave, elastic modulus, tomography

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Diagnostics of Fracture Processes by Measurements of Acoustic Emission

Vladislav Georgeevich KHANZHIN*, Mstislav Andreevich SHTREMEL,
*Metal Science and Strength Physics Department, Moscow State Institute of Steel and Alloys –"MISIS" (National Research Technological University), 119049 Мoscow, Russia
e-mail: v.g.khanzhin@gmail.com, phone: +7(495) 955-0089

Abstract:
Acoustic emission (AE) measurements of failure cover two classes of tasks: 1) testing, monitoring and forecasting of object (construction) behavior; 2) determination of laws of substance failure (in dependence on a structure and test conditions) - for forecast of behavior and optimization of material. The primary information for these tasks is the same: an amplitude and a time of arrival of single AE signals from crack formation. It were observed the models of fracture and AE which can be used for diagnostics of fracture by AE measurement: the phenomenon of the self-organized criticality of cracks; avalanche-unstable cracking; using the concept of fractal dimensions and the law of self-similarity (scaling); informativity of AE pulse amplitude (the models and distribution approximations of amplitudes, information retrieval). It were observed some physical restrictions for models of AE and algorithms of fracture diagnostics: recording facilities; pulse overlap; reverberation in object , calibration. It were described examples of processes which can be used for models of fracture and AE: corrosion cracking of copper and zirconium alloy, hydrogen embrittlement of high-strength steels and hydrides fracture in Zr- 2.5%Nb alloys, failure upon tension and twisting tests of superconductive composite cable.

Keywords: Acoustic Emission (AE), self-organized criticality of cracks, cumulative distribution of AE pulse amplitude, law of self-similarity (scaling) of AE pulse amplitude, hydrogen embrittlement of steels and corrosion cracking of copper, distribution of Pareto

2010-09-01 00:00 Room: Forum Room: Special Sessions
Session: Modeling Theory and Simulations

The Essential Role of Simulation in Optimizing Probes and Inspection Strategies

Deborah L HOPKINS*, Guillaume Andre NEAU,
*Bercli Corp., 94703 Berkeley, USA
e-mail: deborah@bercli.net, phone: 510 717 8859

Abstract:
Examples from industrial applications are used to illustrate how simulation is used to design and optimize phased-array probes and inspection strategies. Complex shapes, joints, attenuative materials, and the need for high-speed in-line solutions are just some of the conditions that create challenges in industrial applications. While the tremendous versatility of phased arrays greatly helps in overcoming many inspection challenges, the extensive options for probes and controllers makes it much more difficult for users to optimize designs and specify hardware requirements. The large number of parameters that must be examined to evaluate competing designs makes laboratory testing cost prohibitive. BERCLI therefore uses CIVA simulation software to perform parametric studies that along with laboratory measurements are the basis for determining optimal probe and inspection configurations. Modeling is used to characterize the beam radiated into structures undergoing inspection, as well as the response of the radiated field to defects. This allows resolution limits and the minimum size of a detectable defect to be determined, as well as the coverage zone. Although modeling does not eliminate the need for experimental validation, it can greatly reduce the number of required experiments. Moreover, both qualitative and quantitative characteristics of an NDT procedure can be evaluated. These modeling and parametric studies are often a necessary step in ensuring that inspection requirements are met and in evaluating the optimal tradeoffs between performance and cost.

Keywords: NDT-wide, Ultrasonic Testing (UT), Modeling and Simulation, Phased array, composites, weld, CIVA

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Theory of Numerical Methods for Computer Simulation of Ultrasonic Waves Passing through the Nonlinear Flaws

Vadim KNIAZEV*,
*Wave Process Simulation System Laboratory, 129110 Moscow, Russia
e-mail: vadim.d.kniazev@gmail.com, phone: +7 916 6812656

Abstract:
In recent years new methods of nonlinear non-destructive testing (NNDT) have been developed. When ultrasonic waves are passing through the dangerous micro-heterogeneities (microcracks, debondings, delaminations and microstructural material damages) modification of the acoustic contact area between the opposite surfaces of these heterogeneities takes place. Nonlinear distortions of the ultrasonic wave result from its interaction with these defects. The nonlinear wave equations are more difficult to analyze mathematically. Breaking of acoustic contact area results in singularity of the functions. In the most cases the analytic approaches to mathematical modeling are not acceptable in acoustic NNDT. In the article it is compared analytical and numerical approaches to nonlinear acoustics. It is described the developed physico-mathematical model and numerical method of its solution. Computer simulation is represented by RF-signals, its spectrums and 2D wave propagation diagrams. The process of non-stationarity acoustic field generation is studied. It is considered practical application and further development of numerical approach to computer simulation of acoustic NNDT.

Keywords: Ultrasonic Testing (UT), Modeling and Simulation, Finite difference time domain (FDTD), Nonlinear waves, Nonlinear acoustic interaction, Modulation

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Capabilities and applications of the CIVA 10 modeling platform

Fabrice FOUCHER, Philippe DUBOIS*,
*EXTENDE, 91400 Orsay, France
e-mail: ohilippe.dubois@extende.com, phone: 0033 6 43 71 50 98

Abstract:
The applications of modeling are numerous and show a great variety: performance demonstration of existing techniques, qualification, probe design (e.g phased arrays), virtual testing, help with diagnosis and data reconstruction. At these different steps of the NDE process, simulation allows to reduce the number of costly mock-ups involved, while helping to improve their performance and understanding. The CIVA modeling platform, developed by the CEA and distributed by EXTENDE, allows to address 3 major techniques: Ultrasonic Testing (conventional UT as well as phased-arrays, TOFD or Guided-waves techniques), Radiographic Testing and Eddy Current Testing. The application fields have become increasingly diverse: nuclear industry, aircraft industry, defense, railways, steel industry, oil&gaz,..This communication focuses on the applications and the recent advances in the capabilities of the software in its latest release CIVA 10.0. A lot of improvements have been implemented, whatever it be regarding the capacity to simulate realistic configurations (in terms of test piece geometries and materials, crack morphologies and transducers) as well as regarding the graphical user interface, in order to ease users' life and gain efficiency. CIVA 10 capabilities will be presented and illustrated on industrial applications and validation cases.

Keywords: Electromagnetic Testing (ET), Radiographic Testing (RT), Ultrasonic Testing (UT), Modeling and Simulation, computer based training,

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Damages in the bridges - Modeling and analysis of defects of cracks and corrosion type

Sougrati BELATTAR*, LAAIDI NAOUAR,
*physics, Faculty of Sciences, Chouaib Doukkali Unversity, 24100 Eljadida, Morocco
e-mail: belattars@hotmail.com, phone: +212 679391350, fax: +212 523342325

Abstract:
The application of the principle of Infrared thermography combined to numerical method permit the analysis of thermal exchange on the structure of civil engineering. The daily traffic on bridges, the moisture of the atmosphere and the tiredness of materials, cause damages even the collapse of these works, if there is not a policy of maintenance and maintenance allowing the detection of possible defects in these structures and the intervention in the convenient period. These degradations can be cracks types (longitudinal or transverse), vacuums, corrosion or due to the accumulation of calcite on the beams and the flagstone… etc. In this work we present a thermal method of non destructive testing, based on numerical modeling in three dimensions, in order to detect defects of the empty type or corrosion in a flagstone of bridge. The influence of nature and the geometrical parameters of these defects, on the response of such structure to a thermal excitation is studied. The numerical resolution of this problem was carried out using a numerical computation software based on the finite element method.

Keywords: Defect, temperature, Numeric, Modelling, Infrared Testing

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