NDT Services from TWI

Ultrasonic Modelling

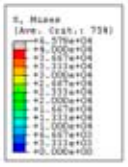
Description

Before taking any sophisticated ultrasonic equipment into the field, it is important to predict the performance of the system on the specific component to be tested. In the past, this has usually been done by carrying out tests on mock-ups of the component in the laboratory. However, more recently numerical modelling of the interaction of ultrasound with the component has found an increasing role. Modelling can be used to reduce the experimental time required and to increase the reliability of on site testing. Modelling can be used for the following:

- Prediction and visualisation of ultrasonic fields
- Calculation of focal points
- Design of phased array transducers
- Analysis of guided waves as used in LRUT and design of phased array focusing in LRUT, including the phasing and power to be transmitted to each module
- Prediction of the interaction of ultrasound with flaws of various types
- Verification of the behaviour of ultrasound in components of complex geometry (e.g. pressure vessel nozzles)

TWI uses three modelling systems.

- Finite element modelling (FEM)
- Acoustic Ideas's Continuum Ultrasonic Modeler™
- CIVA (CEA) – another specialised ultrasonic modelling package



Finite element prediction of focusing of LRUT at a selected position in the pipe wall

Finite element modelling

For many years now TWI has been utilising the Abaqus finite element package to conduct stress analysis, predict heat flow and, in particular to model ultrasound. Examples are:

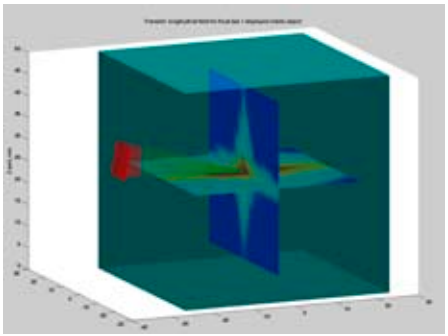
- Guided wave applications
  - Rails
  - Straight pipes
  - Pipes with branches
  - Pipes with bends and elbows
  - Phased array focusing in LRUT (see diagram showing a visualisation of focusing below)
  - Chains
  - Rods (square, round, L shaped)
- Conventional UT of turbine blades

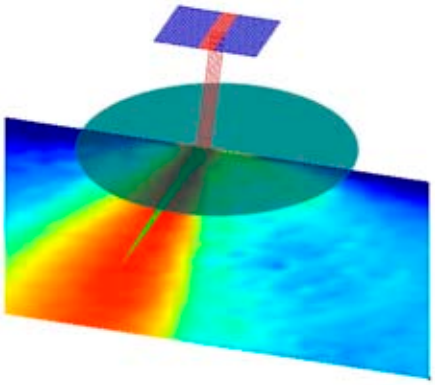
Finite element analysis has the advantage that it is the most accurate method against which other methods can be calibrated. Its principal drawback is that it is extremely demanding in terms of computer time, since accurate modelling of ultrasound requires 8-10 elements for each wavelength.

This means that, at typical frequencies for conventional UT of 1-5mHz, the element spacing should be not greater than 0.2-0.8mm. A 3D model of a reasonable sized component may therefore require a prohibitive number of elements and even for a 2D model the number can be very large. The problem becomes more manageable for guided waves where frequencies are an order of magnitude lower.

Acoustic Ideas Continuum Ultrasonic Modeler™ is a general-purpose ultrasonic modelling package providing the following:

- Calculation of focal laws
- Accurate modelling of ultrasonic fields, including diffraction





Three-dimensional field models using Acoustic Ideas Continuum Ultrasonic Modeler™. The top image shows the intersection of a focused beam generated by a phased array transducer with vertical and horizontal planes. The bottom image shows a detailed visualisation of a focused beam.

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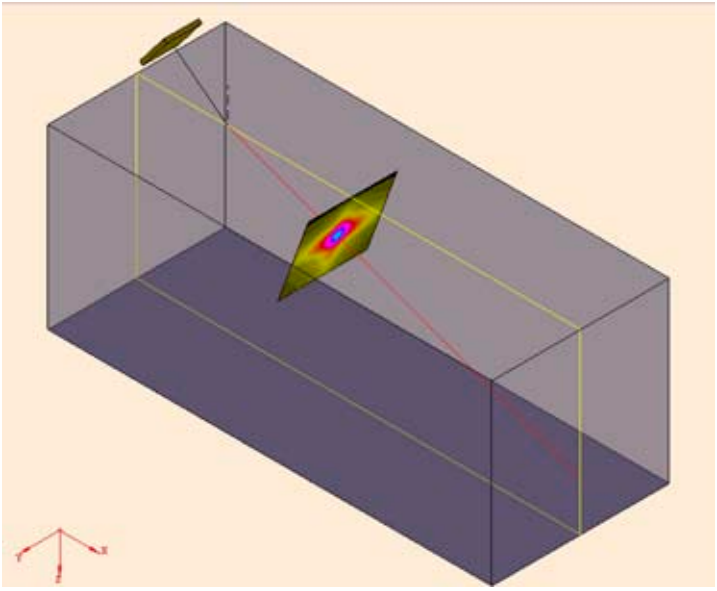
- Visualization of ray paths in multilayer components
- Accurate calculation of scattered echoes from defects
- Interpretation of experimental or field data
- Development and verification of transducer designs

CIVA is also a general-purpose package developed by CEA (France). It is able to model real life inspection scenarios to improve the design of inspection procedures.

A wide variety of geometries can be used including CAD representation making it a very versatile tool. All major ultrasonic transducer types are represented including phased array types and twin crystal probes. CIVA is also able to model a wide variety of engineering materials including those with anisotropy.

Furthermore the user can investigate a wide variety of flaw shapes and sizes, including the standard calibration defects (SDH, FBH, slots etc.) and complex CAD defined rough cracks.

Currently the NDT department of TWI is engaged in the validation of the sound field created by the model against previously validated British Energy models and experimental results.



CIVA image of sound field created by a square crystal inside an isotropic medium

For more information on the services offered in this leaflet, contact:

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