Advanced Tools based on Simulation for analysis of Ultrasonic Data

Souad Bannouf¹, Philippe Dubois¹, Fabrice Foucher¹, Roman Fernandez¹, Stéphane Le Berre²
Outline

- Introduction
- The process of UT data analysis
- Analysis tool n°1: Segmentation
- Analysis tool n°2: Simulation on Acquisition
- Conclusion
Outline

- Introduction
- The process of UT data of analysis
- Analysis tool n°1: Segmentation
- Analysis tool n°2: Simulation on Acquisition
- Conclusion
CIVA in a few words

- Software platform dedicated to NDE modeling
  - Multi-techniques:
    - UT: Ultrasound
    - GWT: Guided Wave
    - RT-CT: Radiography (X-rays & Gamma Rays) & Computed Tomography
    - ET: Eddy Current
    - Analysis & reconstruction tools

- Developed by CEA LIST
  - Research Centre in NDE: 100 people
  - CIVA Development & validation: 30 people

- Distributed and supported by EXTENDE
  - 14 people
  - 10 people for technical support
CIVA UT

Beam calculation:

Interaction with defects:
(Images Ascan-Bscan-Cscan, etc…)

Defects
Backwall echoes

CAD Reconstruction
Module CIVA ATHENA 2D:

- Hybrid computation CIVA (semi-analytical) / ATHENA 2D (FEM code from EDF)
- Accounts for all field/flaw interaction phenomena in a FE box defined around flaw(s)
- Computation time is efficient (2D code, reduced size of the FE box)

Multiple scattering with clusters of flaws
CIVA UT Analysis

UT data analysis:

- A set of « 1 click Tools » for fast and easy extraction of indications from UT Data
- Advanced and Cutting-edge tools:
  - Segmentation, Reconstruction, Signal Processing, Simulation on Acquisition, …
Outline

- Introduction
- The process of UT data analysis
  - Analysis tool n°1: Segmentation
  - Analysis tool n°2: Simulation on Acquisition
- Conclusion
The process of UT data analysis

Objective of the analysis: to obtain an examination report that lists the operating conditions and the indications present in the inspected component.

Analysis can be performed following several steps:

- Validation of the acquisition
- Preliminary signal processing: application of DAC correction; reconstruction of the data in the relevant frame
- Application of detection and characterization thresholds → eliminate false calls or small defects
- Clustering or segmentation algorithms: fast determination of the echoes of interest
- Indication table
Outline

- Introduction
- The process of UT data analysis
- Analysis tool n°1: Segmentation
- Analysis tool n°2: Simulation on Acquisition
- Conclusion
Segmentation

- Goal: grouping signals coming from the same defect or part of a defect

- The algorithm
  - Can be 2D or 3D
  - Grouping based on physical behavior of the ultrasound wave

- Multiple indications can be, if wished, grouped as one (ex: tip diffraction echoes from a crack)

- Creation of an examination report
Application to composite immersion inspection

- Acquisition: electronic scanning of 16 elements with null delay law and 1 element step is associated with a Cscan displacement of the probe

- Step 1: Link the data = combination of electronic and mechanical scanning along the same axis

  Before link

- Step 2: Isolate the flaw's responses with temporal gates

  After link

  After time gating
Application to composite immersion inspection

- **Step 3: Defining a Region Of Interest (ROI) for analysis**

- **Step 4: Activate the Segmentation**
  - Amplitude threshold: level above which the signal will be taken into account during the analysis
  - Spatial resolution: number of successive shots considered to group information
  - Temporal resolution: time window in which the processing will join two points of consecutive shots by a segment
  - Temporal parameter: time window for each Ascan in which we keep only the absolute maximum(s)

- **Step 5: Creation and export of an indication table**
Outline

- Introduction
- The process of UT data analysis
- Analysis tool n°1: Segmentation
- Analysis tool n°2: Simulation on Acquisition
- Conclusion
Simulation on acquisition

- CIVA UT Analysis module also proposes to perform a simulation in a ROI of the acquisition in order to enhance diagnosis.

- Demonstration:

  What is echo n°3, geometry or defect echo?

2MHz, 48 elements

homogeneous stainless steel

slopes of ±10°
Identification of echo n°3

- Echoes n°1 and n° 2 are geometry echoes but is it the same for echo n°3?
- The simulation on acquisition tool lets you simulate geometry echoes in a ROI.

Echo n°3 has not been simulated, it is not a geometrical echo but probably an echo from a planar flaw.
Identification of echo n°3

We suspect Echo n°3 to be a planer flaw. Let’s use the simulation on Acquisition tool to verify it.

Superimposition of acquisition and simulation results
Conclusion

- UT Analysis tool:
  - Helps to quickly evaluate and record indications
  - Included in CIVA 2015 UT or available as a separate module
    - Segmentation in « one click »
    - « Simulation on Acquisition » tool
    - Provides manual data inversion assisted by simulation

- Facilitates processing acquisition data from:
  - M2M systems (MultiX++, Gekko)
  - Olympus (TomoView®, OmniScan®)
  - Compatibility with other formats being currently studied

- Additional demonstration videos available on YouTube: [https://www.youtube.com/user/extendechannel](https://www.youtube.com/user/extendechannel)