Bringing clarity to corrosion mapping

Federico Zottig, Zetec, USA, explains how the latest ultrasonic instruments and software can help with the identification of potentially critical pipeline defects.

When Tibor Szabo started his ultrasonic inspection services business in 2015, the Alberta oil and gas industry was on the cusp of a massive downturn. The price of oil had begun to collapse the previous year, marking the end of a long rally that brought thousands of jobs and substantial investments in plants and pipelines to the industry.

However, the situation presented an advantage to inspection services providers like Szabo, whose company, Polar AUT Services in Sherwood Park, Alberta, specialises in phased array UT (PAUT) and time-of-flight diffraction (TOFD) scanning in the oil and gas business. Asset owners understood the need for more rigorous maintenance and nondestructive testing, which meant that qualified technicians and the latest technology were in high demand.

"Advanced UT and especially corrosion mapping is a highly operator-dependent method of inspection, and being able to acquire and report consistent results is a challenge if you don't have the experience and equipment," said Szabo, who performs corrosion mapping, hydrogen-induced cracking (HIC) testing, and other advanced ultrasonic inspection techniques.

Szabo said one important differentiator in pipeline inspections is the ability to analyse inspection data and provide visual feedback to clients who do not have expertise in ultrasonic testing or corrosion mapping.

Today's advanced phased array UT instruments and software have the computing

power to transform traditional 2D inspection data into full-colour 3D visualisations.

"In a highly competitive inspection environment, the results of UT inspections can have a big impact on decisions about safety, uptime, and code compliance. Having a combination of standard 2D views and 3D views greatly improves the data analysis process, which is a significant benefit to the asset owner and to me as an NDT service provider," Szabo said. "This is especially true when we're plotting and visualising inspection data for the complex geometries that we typically encounter in oil and gas applications."

3D component generation

Generating a 3D work environment is ideally suited for inspection-technique design, validation, and coverage assessment on complex geometries. Whether the surface of the material is flat or cylindrical, thin or thick, coated or not, a 3D visualisation of inspection data can contain enough detail that even clients without a deep understanding of UT scans can easily recognise flaws on the screen.

Figure 1. **The simultaneous use of phased array UT and TOFD can detect all welding flaw types and provide reliable through-wall sizing in one single inspection. They can produce higher detection capability, more accurate characterisations of corrosion and complete coverage of the material under test.**

How does a 2D ultrasound image become visualised as a 3D work environment?

Essentially, the process involves merging data from 'normal' 2D scans taken from different positions and angles, and overlaying the data onto a CAD file or 3D rendering of a weld or specimen that is under test. Ray tracing and beam simulations help determine detection capability and inspection coverage.

The first step involves creating a rendering of the component. The more full-featured ultrasonic testing and analysis software on the market includes a large database of basic renderings of common shapes, components, joints, and welds, including connecting pipes, cruciform joints, T joints, and L joints. For complex or custom geometries, you can import *.SAT files (a common file type supported by all CAD software) or create your own customised specimen using UT data.

3D ray tracing, beam simulation, and verification of inspection coverage

The next step is to design the right inspection plan (scan plan) to establish and verify the inspection coverage using ray tracing and beam simulation.

A UT instrument with a software-generated ray tracing tool can compute and display ultrasound rays propagating in the specimen.

These simulated ray paths can undergo reflection and transmission, including mode conversions and interacting with postulated defects in simple or complex geometries as it happens in real samples. Based on the results, the software can then automatically calculate the optimum acoustical path for reflection.

Ray tracing works in concert with beam simulation. Beam simulation allows you to compute, visualise, and characterise the energy distribution in the acoustic beam generated by any given probe, including single element (conventional UT), 1D linear array, and 2D matrix arrays.

The software's scanner simulation tool then emulates the scanner motion on the component and helps to establish the inspection coverage. You can set up multiple types of scanners depending on the component – table scanners, pipe scanners, polar scanners, and so on – and simulate probes in direct contact or spring loaded, and use the wedge footprint to determine the

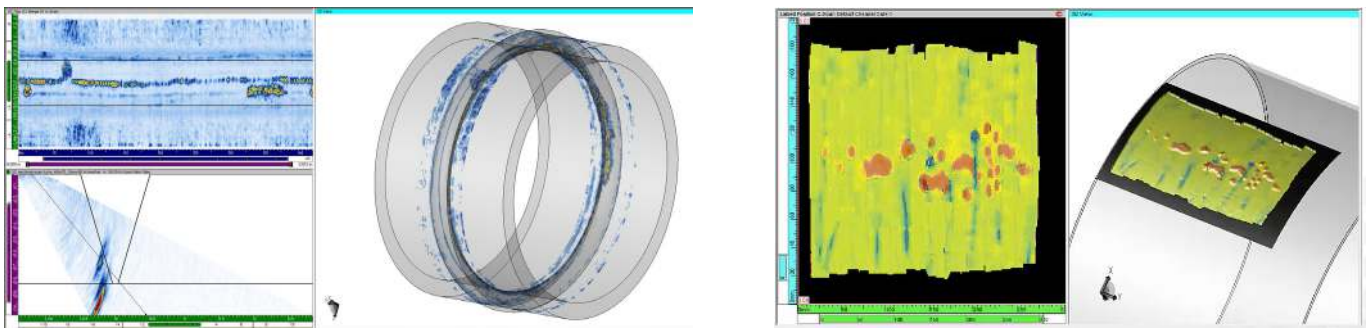

Figure 2. **Advanced phased array UT instruments and software can transform 2D scans and CAD drawings into 3D depictions of corrosion damage and other indications. This type of imaging makes test results far easier to communicate.**

Figure 3. A 2D encoded scanner like Zetec's NDT PaintBrush combines precise data collection with accurate positioning in any direction on flat or curved surfaces, ideal for mapping pipeline corrosion.

2D manual scanners help technicians capture wall-thickness reduction and mapping corrosion

With their compact, lightweight designs, the latest 2D handheld scanners can help technicians deliver complete coverage and accurate manual corrosion mapping of flat or curved surfaces and welds.

Two side-by-side encoded wheels track the position of the scanner in real-time, and allow the operator to monitor the coverage area on the UT instrument display.

Since both axes are encoded, there is no need to draw an index line on the specimen when scanning: the encoders can determine at any instant the probe position and the scanner's orientation.

The first such scanner was Zetec's NDT PaintBrush, developed specifically for detecting wall-thickness reductions due to corrosion, abrasion, or erosion.

Tibor Szabo of Polar AUT integrates NDT PaintBrush with Zetec's TOPAZ portable UT instrument and UltraVision 3D software extension to generate a 3D plot of corrosion data, including a depth reading.

"My probability of detection has increased dramatically compared to other scanners, and because of its size, magnetic wheels, and easy handling I can inspect areas that wouldn't be accessible otherwise," he said.

If there is coverage overlap, the instrument's software will take into account the minimum thickness at the same position; if a portion of the test area has not been scanned, a real-time image will be displayed on the scanner. Szabo can immediately spot a missed area and compensate.

water gap under the wedge and take this into consideration for ray tracing and data plotting.

3D and TOFD

The software's advanced focal law calculator then generates the phased array beams for 1D and 2D array probes and time of flight diffraction (TOFD) configurations.

In a TOFD system, a pair of ultrasonic probes are situated on opposite sides of a weld. One probe acts as a transmitter, emitting an ultrasonic pulse into the material; the other is a receiver. Instead of measuring only for the high amplitude sound waves that reflect off of the back of the component, TOFD calculates the response time of low amplitude waves that are diffracted by the tips of the discontinuities.

Changes in flaws can be recorded and compared over time, creating a valuable history of inspection data.

The simultaneous use of phased array UT and TOFD can detect all welding flaw types and provide reliable through-wall sizing capability in one inspection. The inspector can use a two-sided phased array UT examination with standard shear wave phased-array probes to detect planar and surface-breaking flaws, while the TOFD technique can locate and size embedded flaws and offers accurate through-wall sizing performance.

Using phased array UT and TOFD together can also increase the productivity of the inspection crew simply by reducing the number of scans and manipulations that need to be done.

Advanced data analysis

Once you have a 3D model that can be manipulated to show multiple perspectives of a component, the acquired data then needs to be accurately plotted at the right location in the specimen.

A software-based volumetric merge tool can combine the maximum response of each acoustic beam for any given position in the specimen so you can visualise signals and indications from any source at any position where the acquisition was done. It can take the analysis a step further and provides automatic detection of indications based on criteria you define, such as signal-to-noise ratios and minimum indication size.

Thickness/corrosion data acquired with a 2D scanner can also be plotted and rendered to provide visual feedback of part conditions. For cylindrical or disk-type components, you can use a polar coordinate system with views that can be oriented to the side-view of the attached ray to show the incident plane. The polar cutting planes allow for slicing through the data in R-Theta and Z directions.

Ultrasonic inspection software with a 3D rendering feature can transform a 2D colour map into a realistic image of corrosion damage, wall thickness measurements, and other types of defects.

"The ability to produce beautiful 3D images that illustrate the extent of corrosion, combined with the ability to export all the thickness readings into a customised workbook, means I can provide the customer with everything they need to know about the condition of their asset," says Szabo. "When I write my reports, they're concise because the images and data speak for themselves."