Phased array NDT for rapid detection and repair

Following a visit from The German Society for Non-Destructive Testing (DGZfP), the body that coordinates NDT activities in Germany, SAIW is now gearing up to offer training in phased array and other advanced NDT methods to South African plant and fabrication inspectors. *African Fusion* talks to SAIW's Mark Digby about the technology.

From February 4 to February 13, 2019, two German phased array UT specialists, Wolfgang Kotter and Michael Berke of the DGZfP, the equivalent of the SAQCC in South Africa, visited SAIW to deliver the Institute's first-ever Phased Array UT Level 2 course.

"They came to present to a selected few inspection specialists in South Africa, including myself and Absolom Chiswo, and we will be taking the course further into South Africa," says Digby.

In total, 10 inspection professionals participated, all of whom were already qualified at Level 2 in ultrasonic testing (UT). "Of the total, six of us are already Level 3 NDT professionals, four of whom are from Steinmuller, Rotek, Sasol and Eskom. Of the remaining candidates (Level 2), three were from TÜV SÜD in Middleburg, and we had one independent NDT technician," he adds.

As well as SAIW's Mark Digby and Absolom Chiswo, 10 of South Africa's Inspection professionals participated in the first-ever SAIW Phased Array UT Level 2 course, which was delivered by two German UT specialists, Wolfgang Kotter and Michael Berke of the DGZfP.

"The International Institute of Welding-aligned phase array NDT course will get us to the point where our SAIW NDT lecturers are able to deliver local courses at this level. In the interim, though, DGZfP has agreed to support us with respect to technical guidance for the first course and to advise about additional equipment we may need. The course is an add-on method to our traditional UT course and candidates are therefore required to have qualified at Level 2 in UT before enrolling," he explains.

"It was an intensive 7-day course that included an exam on the last day – and we all spent the weekend at SAIW preparing for it. Wolfgang and Michael were fantastic lecturers, and we hope to have them back to do Time of Flight Diffraction (ToFD) UT training sometime later this year," Digby notes.

Advantages of phased-array UT

Like many NDT techniques, phased array made its first appearance in the medical industry. When pregnant women go for their routine scans, a probe is put onto their bellies and, using a C-section scan, they can instantly see the unborn baby's limbs and heartbeat – and they can even determine the baby's sex.

"As usual, industry was a little slower on the uptake and it took them a few years to realise that phased array could also be used to inspect the integrity of manufactured or in-service components and weldments," Digby tells *African Fusion*.

Phased array enables inspections to be completed significantly faster than traditional UT, while at the same time substantially more information can be collected and stored. "For instance, if scanning a weld using traditional UT-technology, then several different probes – with 0°, 45°, 60° and sometimes 70° angles – have to be used to cover the entire weld volume. One probe will scan the bottom of the weld, another the fusion zone and a third probe for the top edges, for example.

"In addition, each probe has to be moved backwards and forwards next to the weld – a process known as rastering – to ensure that the ultrasonic waves are directed towards every possible flaw location," Digby explains.

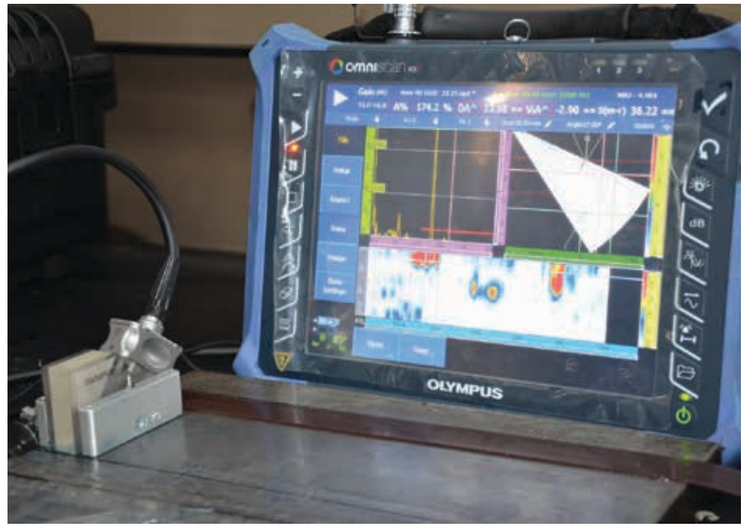
"With phased array UT, a single probe can cover all these angles and many more without having to do rastering. Now an entire weld can be inspected by sliding the probe laterally along the length of the joint," he says.

SAIW is currently working with OmniScan MX2 phased-array equipment from Olympus for its training. "These machines are fully digital and incorporate many features to make the inspection tasks easier. Based in plate thickness and weld configuration, for example, the OmniScan will work out the optimum scanning position alongside the weld. Simply put, it will tell you where to place the probe." Digby adds.

Explaining the difference between phased array and traditional UT, he says a traditional UT probe consists of a crystal, which generates the ultrasonic wave, and a casing, which holds the crystal at the steering angle of the probe. "So different probes are needed for each angle. Typically, three or four have to be systematically used to ensure that the full weld volume is inspected."

Phased array technology replaces one crystal with an array of crystal elements in a single casing. Probes can have 8, 16, 32, 64 or even 128 individual ultrasound generating elements. "Our OnmiScan probes, for example, have 64 elements. Combinations of these can be made to fire at various angles, which means that, collectively, one phased array probe can scan an entire weld from a single position," Digby informs *African Fusion*.

The elements can be split up into arrays of 16, for example, so that each set of element arrays creates an ultrasonic wave-front in a different direction. If using a 64-element system, this will create four different angles that fire from the same probe position.



SAIW is currently working with OmniScan MX2 phased-array equipment from Olympus for its training. "These machines are fully digital and incorporate many features to make the inspection tasks easier. Multiple views of the results are displayed at the same time on the monitor. A-scans (top left) show only the position of a potential defect or reflecting surface, while the B- and C-scan images (bottom and top right, respectively) show different 2D views of the relative position and size of the indications.

How is the firing angle varied? "The software in the machine sequences the firing times so that the individual waves interfere with each other, creating new wave fronts at different angles. It's all based on the science of constructive and destructive interference," he responds.

In addition, phased array probes can be mounted on angled wedges, which can be used to create shear waves in addition to longitudinal ultrasonic waves. Shear waves tend to travel a lot slower, so they deliver better sensitivity and resolution. Very fine defects such as fatigue cracks can be reliably detected and monitored using this technique," he says.

Multiple views of the results are displayed at the same time on the monitor. "A-scans show only the position of a potential indication or reflecting surface, while the B- and C-scan images show different 2D views of the relative position and size of the indications," Digby explains.

Being digital, phased array UT machines can store large amounts of inspection data and they embed software that enables inspection reports to be generated quickly and immediately after an inspection is completed. Where required, images of the inspected component can also be embedded into the reports. "The data collected can be copied onto memory cards for uploading onto computer systems, emailing to clients or archiving for long term traceability," notes Digby.

"Phased array UT is being used more and more, sometimes to replace traditional UT inspections but, increasingly, as an alternative to radiographic inspection (RT). Inside a boiler, for example, boiler tubes were historically X-rayed. Due to safety concerns, it meant all the welders, grinders and workers anywhere in the vicinity of the inspection area had to stop and move away.

"Using phased array UT, an inspector and a welder can work side by side. As soon as the weld cools down sufficiently to be touched, a phased array inspection can be completed. The results can be viewed online by the welder, who can see exactly what is going wrong and, if allowed, the problem can be fixed immediately and the welds retested," he says.

"If using X-ray technology, the entire area would have to be cleared before X-ray exposure. The films would then be taken away for processing, which could take days. If there was a problem, the maintenance team would have to be informed to reschedule the repair and the repaired weld would have to be re-radiographed.

In terms of the possibility of detection, Digby says phased array offers better reliability and sensitivity. "We are now finding things that have been invisible in the past, such as fine cracks and small areas of lack of fusion. Phased array has been found to be excellent in exposing such imperfections," he concludes.