Importation of CAD file improves and simplifies the evaluation of inspection results from complex geometries for Advanced Ultrasonic Phased Array Inspection

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Abstract

Phased Array technology plays an important role in the non-destructive inspection industry, because it allows to capture much more data compared with conventional ultrasonic and thus increases safety and product quality.

Over the years many new important features have been implemented in Phased Array Flaw Detectors such as the DUET technique with simultaneous inspection from two sides of the weld, with and without applying ToFD inspection, coupling control and many more.

One of the difficulties with evaluating the results of a Phased Array Scan on complex geometries has now been resolved in a very productive and easy way. A new feature allowing the import of a CAD file is now available so that the geometry of the part inspected becomes visible on the instrument screen.

Keywords: Phased Array, Ultrasonics, Advanced Ultrasonics, CAD importation, PA evaluation

1. Calibration challenges in Phased Array Inspection

The target of any ultrasonic inspection utilizing Advanced Instrumentation such as Phased Array Equipment is to perform testing in a code compliant manner. It means that the equipment must be calibrated in such a way, that reflections from particular flaws used for calibration (e.g. side drill holes) in different depth or distance in the material shall be shown on the instrument screen with the same amplitude height independent from the angle of incidence and independent from the distance.

1.1 Calibration Procedure DAC / TCG (example: weld inspection)

Figure 1 shows a calibration block with several side drill holes of 3 mm diameter in different depth of the material. Such a calibration block may be used to create the DAC (Distance Amplitude Correction) curve, which shows the dependency of the amplitude for the reflected signals relative to the distance of the reflector.
Figure 1: Typical DAC calibration block and reflector close to the PA Probe

The further away the reflector, the lower the amplitude of the reflected ultrasonic wave (Figure 2).

Figure 2: Typical calibration block and the reflector far away from the probe.
The procedure to create a DAC curve is the same as in conventional ultrasonic inspection. The DAC curve is also the base for the TCG function (TCG = Time corrected gain). Applying the TCG function will equalize all amplitudes so that flaws are shown with the same amplitude independent from their distance.

![Figure 3: Typical DAC curve](image)

1.2 Calibration for Angle/Gain Compensation

In conventional ultrasonic inspection the probe is manually moved in a zig-zag mode in order to capture reflections from flaws in different distances (locations) using a probe with one particular incidence angle (Figure 4 - left). In Phased Array inspection the PA probe is moved parallel to the weld (Figure 4 – right) and the PA instrument is automatically transmitting ultrasonic waves under a range of incidence angles (e.g. from 40 to 70 degree in steps of 0.5 degree).

![Figure 4: Scanning with conventional probes in “zig-zag” mode and in parallel to the weld with PA probes](image)

Since the created ultrasonic waves will not provide the same amplitude height from a calibration flaw (e.g. 3mm side drill hole) under different incidence angles, it is required to equalize all amplitudes received under the different angles. This is done when the Angle/Gain calibration is performed. Once the amplitudes from a calibration flaw are captured under different angles, the resulting curve is applied and the instrument is automatically compensating for the differences and equalize the amplitude heights.
1.3 Applying DAC and Angle/Gain compensation leads to code compliant PA inspection

Figure 6 shows the final result for scanning on a PA calibration block. All amplitudes are now at the same height independent of incidence angle and independent of reflector distance. Means: All reflectors are shown in same color.

2. The challenges in evaluating PA scans inspections

Ultrasonic waves are not only reflected from flaws in the material. The waves are also reflected from the geometry of the part being inspected. In Phased Array weld inspection it is quite common that flaws are detected two times in the sector scan during PA inspections; directly in the first skip and indirectly after the sound wave was reflected from the backwall and then hit the flaw under a different angle (second skip). It is still rather easy to evaluate such scan results as long as the part inspected has a simple
geometry like a planar weld (see Figure 7). If the geometry of a part to be inspected is more complex, it becomes more difficult. Especially distinguishing between reflection from the geometry and reflections from flaws can became a challenge (see Figure 8).

![Figure 7: Planar weld – Flaw is detected and shown twice in Sector Scan](image)

![Figure 8: Common presentation of the Sector scan – difficult to analyse!](image)

3. **Tools and features to simplify the evaluation of PA results**

For some years already several manufacturers tried to simplify the evaluation either by implementing supporting lines in the Sectorscan representing half a skip, full skip, one and a half skip or two skip of a particular weld and also display the weld preparation on the screen. Another solution is to use special software where it is possible to define the geometry and display it on screen together with life data of sound waves with all its reflections from the geometry. This is certainly the best solution, but not very economical as the user of the PA equipment needs to have special software for the different inspection jobs on different geometries.

Today most of the leading manufacturers such as Olympus, Eddify/M2M and DOPPLER implemented the special feature of loading the CAD file of the part to be inspected into the instrument and then display the geometry on the screen (Figure 9). This approach is certainly a new milestone in advanced
Ultrasonic Inspection Technology and makes life easier for everybody who needs to evaluate scans utilizing advanced Phased Array Technology.

Figure 9: With the geometry displayed on screen of the part being inspected evaluation becomes easy