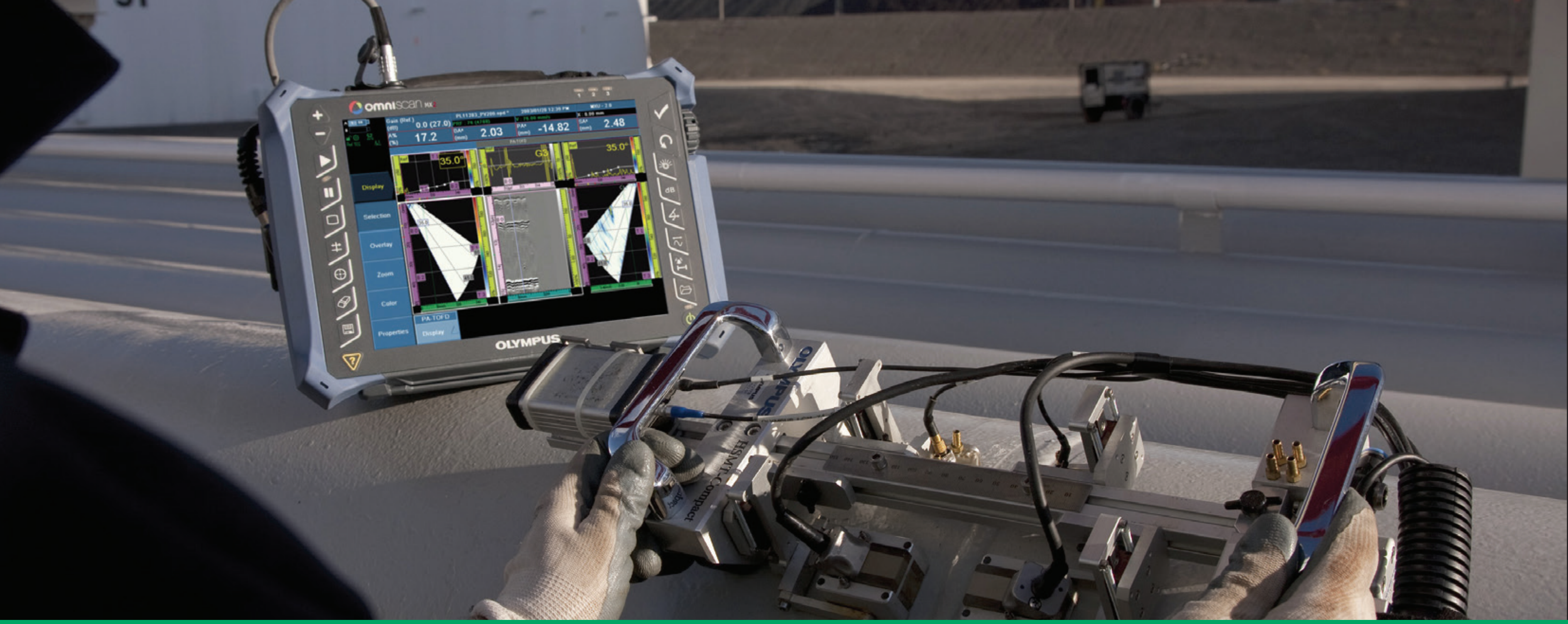


SOUNDS GOOD – USING ULTRASOUND FOR SAFER PIPELINE INSPECTIONS

When inspecting pipelines, welds require special attention. Many types of defects can lower the strength of a weld, forming possible locations for pipeline failure. Furthermore, so-called dissimilar-material welds, which are frequently used to create components with improved or tailor-engineered properties, can be hard to inspect.

Radiographic inspection is often used for pipeline inspection and is commonly seen as a gold standard. However, radiography carries important safety concerns due to the use of harmful X-rays. Inspections using ultrasonic flaw detectors address these concerns and detect weld defects fast, with high precision and without harmful radiation.

Regular inspection of pipelines used for transporting gas, oil or other chemicals is essential to prevent costly leaks and spills, and to ensure compliance with safety standards. When pipelines are welded, these welds are often the weak spots where damage is more likely.

Welds can contain a multitude of different defects. These can be introduced during production, either as a result of incorrect operation of the equipment or due to an incorrect welding setup. Additionally, prolonged use of pipelines can introduce new defects or cause further damage to existing faults. Common examples of defects in welds include porosity, lack of fusion, slag inclusions, root or toe cracks, and incomplete penetration (figure 1).

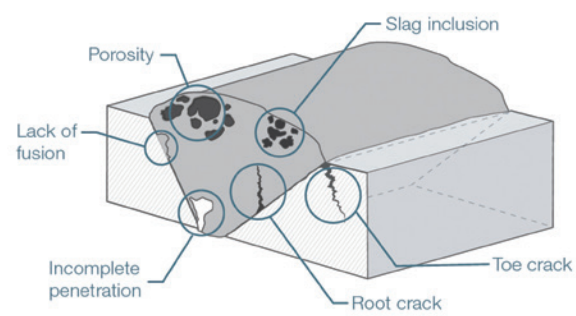


Figure 1: Different types of weld defects can significantly weaken the bond between the components that are being joined together.

All these types of defects can significantly affect both the quality and the lifetime of a pipeline, which means that welds require particular attention during the inspection process. Nondestructive testing (NDT) methods are commonly used to inspect in-service pipelines as they can extend the lifetime of pipelines without compromising safety.

When using NDT it is important to consider the material properties of both the weld and the parent material. For example, the oil and gas and petrochemical industries use more and more pipelines consisting of carbon steel coated with a corrosion-resistant alloy (CRA) (figure 2). CRA can also serve as a filler material in girth welds. Interfaces in these 'dissimilar-material welds' can present a problem in NDT and a thorough understanding of the properties of the materials involved is necessary to create the right inspection setup.

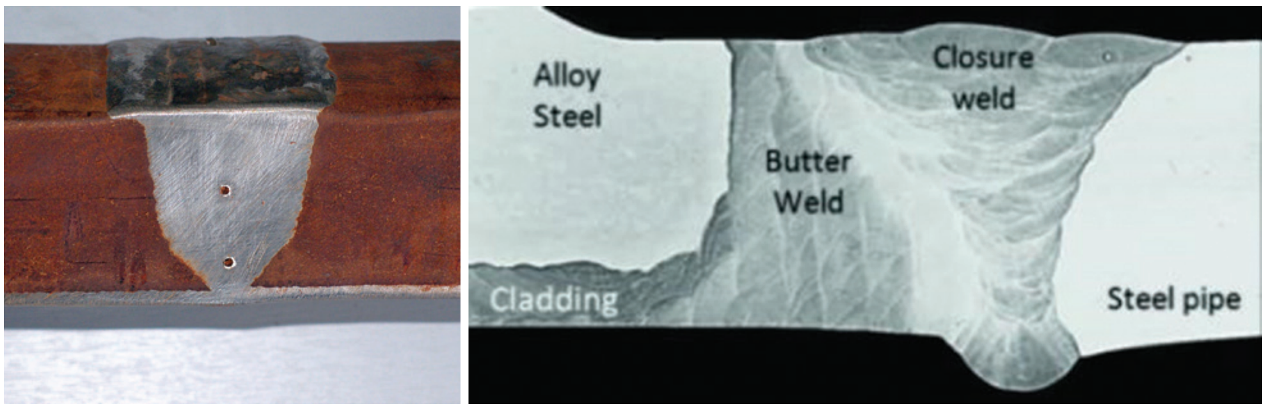


Figure 2: A weld with a different material to the component itself (left) and a weld that joins two different materials together (right).

Using X-rays to inspect pipelines

One well established technique to examine damage to components such as pipelines is radiography. In a typical radiography setup, a source of high-energy X-rays is placed on one side of a component and a detector on the other. X-rays of different energies have different levels of attenuation when travelling through a component – an effect that can be used to optimise contrast in the image on the detector.

When inspecting components using radiography however, there are important safety aspects that need to be considered. X-ray radiation is harmful to humans and strict legislation is in place to protect workers. As a result, an area around the inspection site needs to be cleared of people when the inspection is taking place, causing disruption to ongoing work in the area.

When it comes to detection of defects each method will have different probabilities of detection depending of the type of defect. It is therefore important to be aware of the most likely and the most critical defects when choosing an NDT inspection technology.

One defect that can significantly reduce the strength of a weld is the lack-of-fusion defect (figure 3). Lack of fusion occurs when the melted metal that is applied to join two pipes together fails to melt the parent material and simply solidifies on top of it. Lack of fusion can take place between beads of weld material or between the weld and the parent material. In both cases it leads to the formation of a bond with low strength.

Due to the fact that lack-of-fusion defects are often thin and flat, radiographic detection depends highly on the orientation of the defect with respect to the X-ray source. Under certain angles these defects are almost impossible to see with radiography-based imaging.

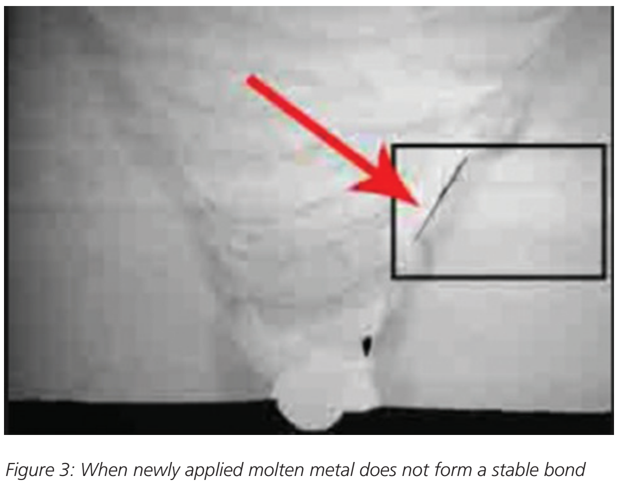


Figure 3: When newly applied molten metal does not form a stable bond with the underlying material, a lack-of-fusion defect can form.

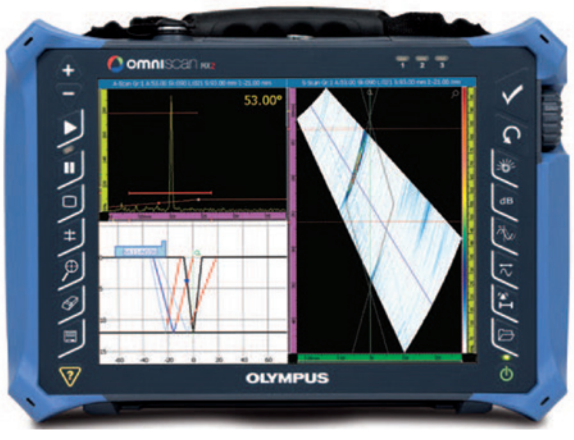


Figure 4: Ultrasonic flaw detectors control multiple elements to offer versatility with respect to the beam's orientation.

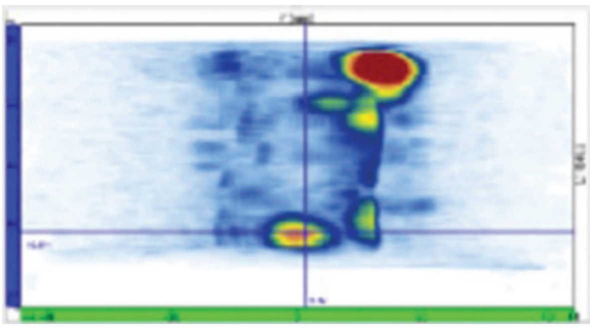


Figure 5: The use of multiple-element transducers for transmitting and receiving helps to reduce noise in inspecting challenging materials.

A final drawback to the use of radiography for inspection of pipelines is the time it takes to create an image with sufficient brightness and contrast. Exposure times depend highly on the material and its thickness, but can take anywhere from a few minutes up to several hours.

Utilise the power of sound waves

Ultrasound (UT) inspection is a commonly used alternative to radiography for inspecting welded components. UT works by generating high-frequency sound waves, which travel unimpeded through many uniform materials, but deflect off boundaries between different materials, such as flaws. This phenomenon makes ultrasound highly suitable for flaw detection.

There are different setups available to carry out pipeline inspection using UT, depending on the resolution and noise levels required. One of the main choices when using UT is between a pulse–echo and pitch–catch configuration. In a pulse–echo configuration, a signal is detected by the transducer that also emits UT waves; the pitch–catch technique uses two separate transducers. The pitch–catch technique, also known as the transmit–receive longitudinal (TRL) technique, produces a less noisy signal when inspecting difficult materials.

Advance inspections with phased array

Another parameter that has a large impact on the quality of the inspection – and therefore on the probability of detection – is the number of UT elements in one transducer. Conventional UT uses one-element transducers, but advanced inspections, such as those using imaging and sectorial scans, require a so-called ‘phased array’ of elements.

Phased array transducers work by using multiple elements, each of which produces its own UT waves. By carefully controlling each element, phased array flaw detectors such as the Olympus OmniScan MX2 (figure 4) can exert better control over the UT beam, allowing more precise inspection with a higher probability of detection (figure 5).

Combining the benefits of phased array and pitch–catch inspection, dual matrix array (DMA) probes can be used to enable the most comprehensive inspection of welds (figure 6). Among the benefits of DMA probes are imaging capabilities, sectorial scans and easy coverage of a weld without moving the probe back and forth. These benefits simplify inspection for an improved probability of detection.

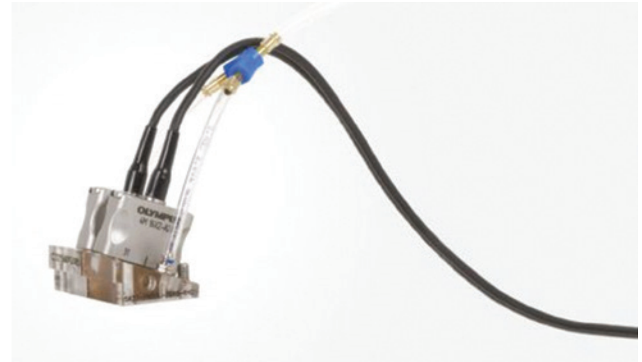
When it comes to inspecting complex welds, such as dissimilar-material welds, the accuracy and precision of phased array probes improves flaw detection. Phased array gives the operator more control over the beam and DMA probes with different frequencies can be used depending on the type of material to be inspected. For example, low-frequency 1.5 MHz probes are suitable for inspections where wave propagation is challenging, such as materials with a large grain size.

Faster and safer weld inspections

Ultrasonic phased array inspection for large-scale weld inspections can offer important benefits over radiography. The main benefit of ultrasound is safety: the absence of X-rays means that there is no need to clear the area around the inspection site. Not only does this improve safety for staff, it also causes less disruption to other activities in the area.

With respect to precision, ultrasound can offer superior probability of detection of certain weld defects compared to radiography. For example, when it comes to detecting lack-of-fusion defects, the orientation of the defect can be misaligned with respect to the direction of the X-ray radiation, which leads to low contrast in radiography.

The speed of inspection is also an important consideration when selecting inspection equipment. This is also an area in which ultrasound offers benefits; typical ultrasonic inspections can be completed quickly with data analysis performed on-site. The speed of radiographic inspection is highly dependent on exposure times, which can be anywhere from a few minutes up to several hours for one weld, depending on the material of the weld.



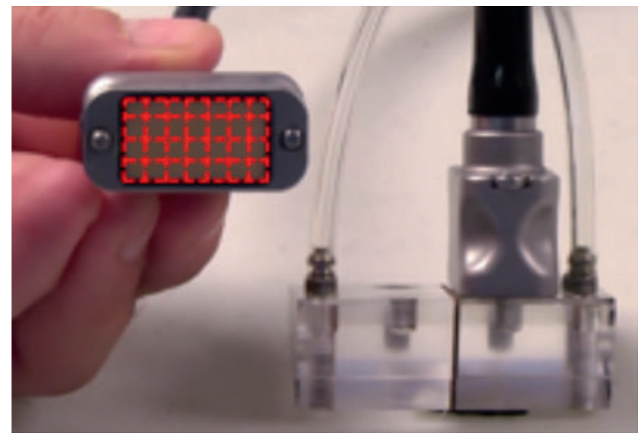


Figure 6: A DMA probe consisting of two transducers, each containing 28 elements

Summary

Regular inspections of pipelines improve safety for staff and prevent costly failures and the associated repairs. NDT is well suited for inspecting pipelines on a large scale. Radiography has long been the gold standard for pipeline inspection, but comes with important safety concerns – as well as problems with the detection of certain defects such as lack of fusion.

A setup using UT flaw detectors, such as OmniScan MX2, and phased array DMA probes has the capability to inspect large sections of pipelines quickly, reliably and without the use of harmful radiation. It also offers high probability of detection in hard-to-inspect locations such as dissimilar-material welds. These benefits mean that UT scans are less disruptive and improve safety in industrial pipeline inspections.

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