In-Service Inspections Using EMAT and MRUT

EMAT Overview

Readers were previously introduced to the practical advantages of EMAT Ultrasonic Testing that include dry inspection, an imperviousness to surface conditions, and unique wave modes such as shear waves with horizontal polarization (SH waves). This second installment will cover the practical advantages of EMAT in the field of in-service applications using Medium Range UT (MRUT).

As a review, EMAT, or Electro Magnetic Acoustic Transducer, is an Ultrasonic Testing (UT) technique that generates the sound in the part inspected instead of the transducer. As illustrated in **Figure 1**, EMAT generates ultrasonic waves into a test object using electromagnetic induction with two interacting magnetic fields. A relatively high frequency (RF) field generated by electrical coils interacts with a low frequency or static field generated by magnets to generate a Lorentz force in a manner similar to an electric motor. This disturbance is transferred to the lattice of the material, producing an elastic wave. In a reciprocal process, the interaction of elastic waves in the presence of a magnetic field induces currents in the receiving EMAT coil circuit

Because the sound is generated in the part inspected instead of the transducer, EMAT is a completely non-contact technique that has significant advantages for in-service applications over more conventional piezoelectric inspection techniques. More specifically, in this article, we will discuss the applications and techniques deployed when using guided waves with a MRUT system.

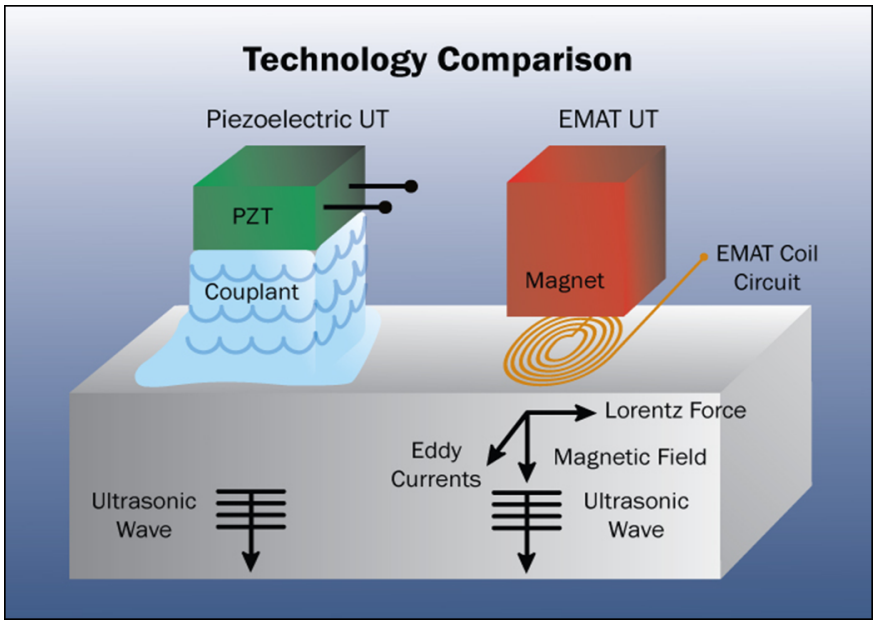

Figure 1 UT Technology Comparison

In-Service Inspection Methods and Equipment

The two most common methods for in-service inspections with guided waves are Long Range UT (LRUT) and Medium Range UT (MRUT). LRUT is used almost exclusively for pipeline inspection in reflection mode to cover long distances (tens of meters) from a fixed ring of sensors. It normally works with low frequencies (sub-100kHz). Typical detection capabilities are 10% of cross-sectional wall loss. MRUT is used in both attenuation and reflection mode to cover shorter distances (0.1-5m). The sensors are mounted on scanners to inspect long stretches of pipe or tanks. It typically works with frequencies from 100kHz to 1MHz, and can detect small pits (approximately 10 times more sensitivity than LRUT).

The temate® Medium Range UT (MRUT) uses high frequency guided waves with a typical inspection range between 4" (0.1m) and 16' (5m) to detect corrosion, cracks and discontinuities on exposed tubes, gas lines, oil pipelines and storage tanks. The system uses high-power EMAT technology to perform 100% scanning at speeds of up to 150mm/s on pipe diameters from 2.0" (50mm) to 46.0" (1168mm) with 0.5" (13mm) or less wall thickness. The inspection can be performed on rough and corroded surfaces and when covered with thin wraps and coatings (<3mm).

The equipment can be configured with a hand-held instrument and scanner for smaller, easy-to-access jobs, or a high-speed, portable system with an automated crawler for fast scanning and climbing on pipes and tanks horizontally and vertically. The hand-held instruments are designed to be used with permanent magnet sensors, while the high-speed system can be used with permanent or pulsed magnet sensors for superior signal-to-noise. Both equipment options are suitable for axial and circumferential scanning techniques.

The equipment includes sensors and software configurations to excite guided wave modes for different thicknesses and environmental conditions. With the use of higher frequencies and a shorter range, the MRUT technique detects isolated pitting and wall loss with up to 10 times better resolution than Long Range UT systems with minimal or no dead zone.

In-Service Applications

Pipe & Tank Inspection – The MRUT technique using Shear Horizontal and Lamb guided waves is an excellent choice for quick screening and detection of cracks, pits, and corrosion on in-service pipes and tanks. The applications include:

- Inspection under supports - One of the most problematic areas for corrosion. It works for both pipelines that are welded, or standing on supports.
- Air-to-soil interfaces - Using non-leaking guided waves, the technique can be used for inspection of the first 1-2m of an inaccessible structure (buried or hidden).
- Tanks - When mounted on a crawler, it permits covering large sections of the tank (1m) for quick screening and assessment.

- Free-standing pipeline - Detects smooth corrosion, pitting and cracks on free-standing pipelines with minimum insulation (less than 3mm).

MRUT Scanning Techniques

On relatively thin structures, it is possible to generate guided waves that fill up the material and permit a complete, volumetric inspection. The most common types of volumetric waves are Lamb waves. The transmit and receive sensors can be configured in either Pitch-Catch or Pulse-Echo configuration depending on the type of scanning technique in use. There are two types of scanning techniques that can be employed with an MRUT system, axial and circumferential

Axial Scanning

Axial scanning (**Figure 2**) is a through transmission technique that achieves100% volumetric pipe inspection through rapid ultrasonic sampling of the pipe circumference as the sensor is moved along the length of the pipe. Ultrasonic sampling is provided up to 400 readings per second.

Pulse-echo sensor configuration measures ultrasonic transmissions around the pipe circumference. Transmit and receive elements are positioned less than 180 degrees apart around the pipe outer surface. A volumetric guided wave is produced and sent in both directions, clockwise and counterclockwise directions. The strength of both transmissions are measured by the receiver element. Defects, such as cracks, pits and wall loss, provide observable attenuation of the sound or phase shift due to time of flight change.

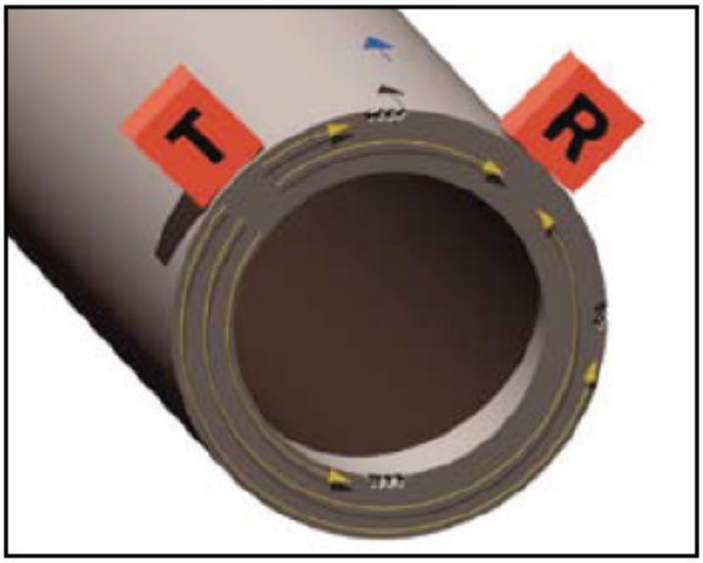

Figure 2 Ultrasonic EMAT method for axial scan of pipe.

Circumferential Scanning

Circumferential scanning (**Figure 3**) is a through transmission technique that achieves 100% volumetric pipe inspection through rapid ultrasonic sampling of the pipe as the sensor is moved around the pipe circumference. Ultrasonic sampling is provided up to 400 readings per second.

Pulse-echo sensor configuration measures ultrasonic reflections down the length of the pipe. Defects, such as cracks, pits and wall loss, provide observable reflections of the sound.

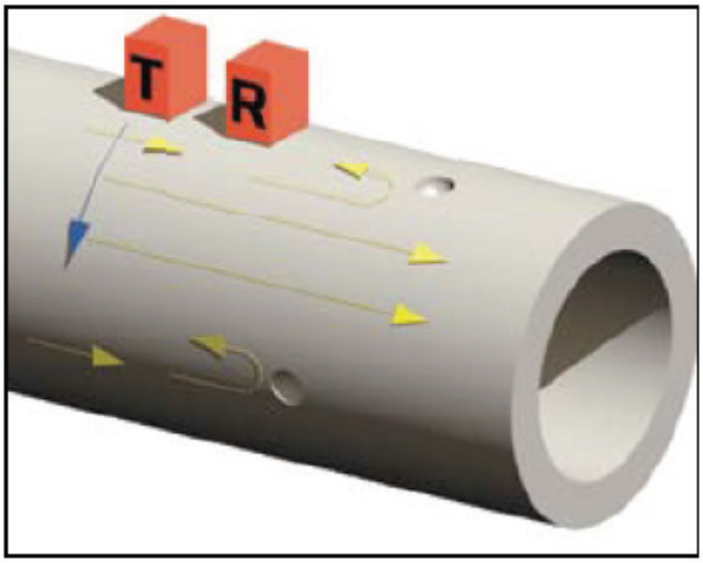

Figure 3 Ultrasonic EMAT method for circumferential scan of pipe.

Conclusion

As a non-contact UT technique, EMAT has distinct advantages that make it the technique of choice for many applications. When combined with MRUT sensors and methods, the advantages of EMAT translate into an effective high-speed scanning system for in-service applications.