# NDT Services from TWI

## Non-Contact Ultrasonic Testing

### Description

Non-contact ultrasonic testing (UT) has advantages and disadvantages compared to the more common system where the ultrasound is generated by a piezoelectric crystal. The advantages are that:

- No couplant is needed. Thus the reliability of the scanning process is enhanced.
- The component's surface does not require preparation.
- It can be applied when the surface temperature is too high for a contact probe.

Disadvantages are that:

- The transmitted ultrasonic energy is relatively low.
- EMATs can only be applied to conducting materials and laser excitation cannot be used with plastics and composites.

TWI is developing several systems of non-contact UT; electro-magnetic acoustic transducers (EMATs), laser generation and detection and air coupled acoustic transducers. These types of non-contact transducers can be combined to suit particular applications. For example both EMATs and air coupled transducers can be used as detectors for laser generated ultrasound.

**EMATs** can generate and detect ultrasound in conducting materials. They have two essential components – an electric coil and one or more permanent or DC magnet(s). Current in the coil is cycled at the desired frequency. This induces eddy currents in the test material. These, in the presence of the magnetic field, cause oscillating Lorenz and magnetostrictive forces in the material, thus generating ultrasonic waves.

*EMAT wall thickness measurement of boiler tube. To demonstrate the non-contact nature of the EMAT, it is operating through a plastic (non-conducting) ruler.*

The reverse processes apply so that ultrasound in the material generates eddy currents, which, in turn, induce currents in the coil. Thus the transducer acts as transmitter and receiver. Depending on the arrangement of the coil and the magnet(s) a wide range of wave types can be generated (normal beam shear, angle beam shear, horizontally polarised shear (SH) plate, Rayleigh and Lamb).

Boiler tube wall thickness measurement is readily carried out using EMATs to generate shear waves at normal incidence. The high temperature oxides that form in the boiler (magnetite and hematite) have excellent magnetoelastic coupling giving higher amplitude signals.

In **Laser UT**, a high power pulsed laser heats a spot on the surface of the test material and rapid thermal expansion generates ultrasound. The frequency content is related to the laser pulse rise time. A Q-switched Nd:YAG laser with a typical pulse duration of 5-10ns generates broad ultrasound up to ~15 MHz. The ultrasound can also be detected optically, as an ultrasonic wave arriving at a surface causes a small displacement, which can be measured using an interferometer.

In TWI's system excitation is provided by an Ultra Compact Folded Resonator (CFR) Q-switched Nd:YAG laser manufactured by Big Sky Laser Technologies and marketed by Quantel. The 50 mJ laser operates at 1.06 µm (near infrared) and is delivered through a 1mm diameter Fibre Optic Launch Adaptor (FOLA). The interferometer is a Quartet manufactured by Bossa Nova Technologies and is capable of operating on unprepared surfaces in an industrial environment.

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The interferometer is based on a frequency doubled Nd:YAG 60 mW green laser and operates at 532nm. Different wavelengths are chosen for the generation and detection lasers, so that the interferometer is not saturated by scattered light from the much stronger generation laser.

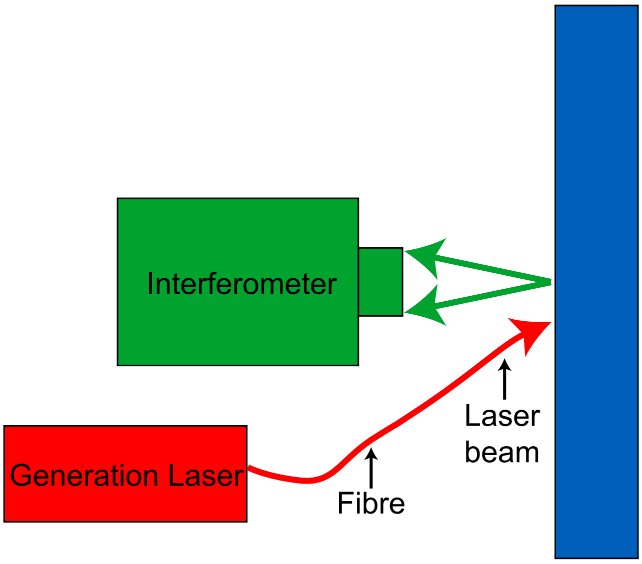
The generation and detection of the ultrasound is coincident. This type of pulse echo is commonly used for testing aerospace composites for thickness and delamination.

The advantage of the Laser-UT systems is that the component is not contaminated by couplant and both generation and detection beams can be optically scanned,

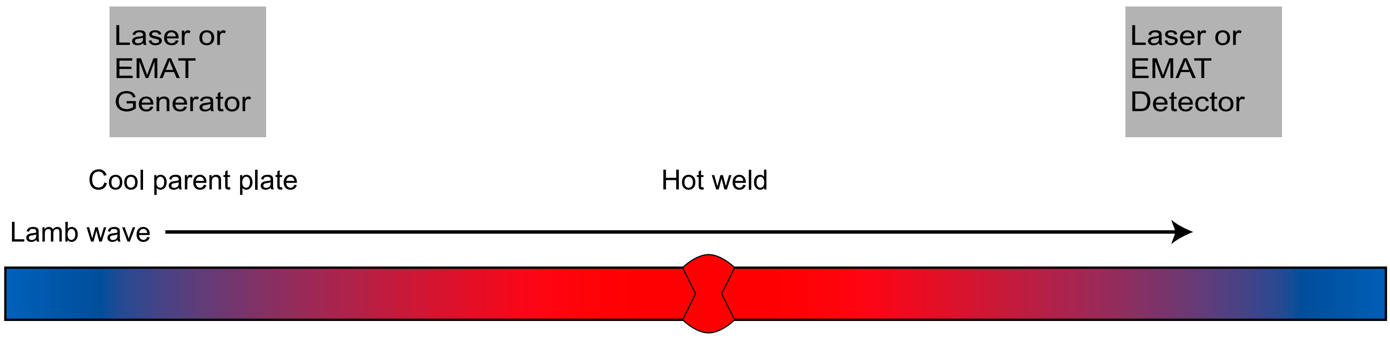
Other applications of Laser-UT include high temperature testing, for example wall thickness measurement on seamless steel tube during manufacture and monitoring microstructural phase changes.

Non-contact ultrasound can also be used for the on-line monitoring of welding processes.

A Lamb wave can be launched in the plate on one side of the weld and transmitted through the hot weld. The amplitude of the detected wave can be used to monitor weld quality. Lasers or EMAT (or a Laser-EMAT system) can be used for this purpose. The EMAT can be placed a few inches from the weld where the plate is relatively cool. Uncooled EMATs can operate continually at temperatures up to 300°C.




*Scematic of a laser generated ultrasound pulse echo set up*




*Typical set up for on line monitoring of welds*

For more information on the services offered in this leaflet, contact:

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