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VEQTER

Residual Stress Experts

VEQTER is an engineering company providing excellence in the measurement, analysis and management of residual stresses. We are world leaders in our field and offer expertise on any aspect related to residual stresses in engineering components and structures.

Ultrasonic Technique

Ultrasonic waves are commonly used to detect flaws in engineering materials, however they can also be used for the measurement of applied and residual stresses. The Ultrasonic stress measurement technique is the only portable technique that can provide non-destructive, through-thickness stress measurements in a wide range of materials.

The technique exploits the acoustoelastic property of materials by measuring the velocity of ultrasonic waves travelling through a component. An increase in velocity indicates the presence of compressive stresses and conversely a decrease indicates tensile stresses. Near-surface stresses can be measured using critically refracted longitudinal waves with the ultrasound transmitters and receivers being attached to acrylic wedges. Through-thickness stresses are measured using both longitudinal and shear ultrasonic waves with transmission or reflection probe systems.

The technique is best suited to measuring relative changes in stresses within a material, however with careful and accurate calibration the relative measurements can be transformed into absolute values, accounting for temperature and microstructure variations.

To find out how VEQTER can help you please contact us on +44 (0) 117 992 7970 or using experts@veqter.co.uk

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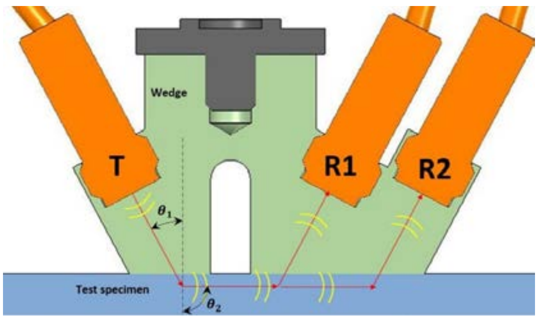
Ultrasonic Technique principle:

The sensitivity of ultrasonic waves due to stress, the acoustoelastic effect, depends upon the direction of wave propagation and particle movement relative to the stress direction; when all three directions coincide then the acoustoelastic effect is most strong. Therefore it is acknowledged that longitudinal ultrasonic waves are the most sensitive to changes in stress as opposed to shear waves.

For near surface measurements, it is possible to produce a critically refracted longitudinal wave (Lcr) travelling just beneath the surface using Snell's law, which calculates the material specific angles to fix the transmitting and receiving probes in an acrylic wedge, see the figure below. The depth of penetration of the Lcr waves is inversely dependent to the frequency of the ultrasonic waves produced.

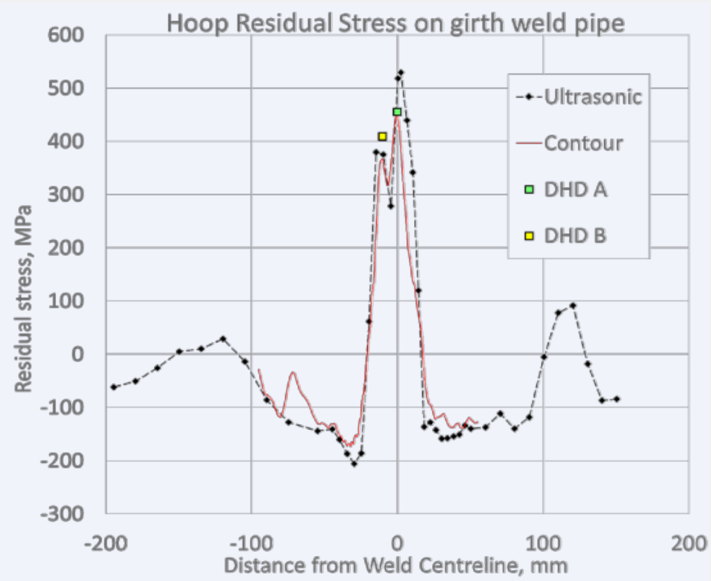


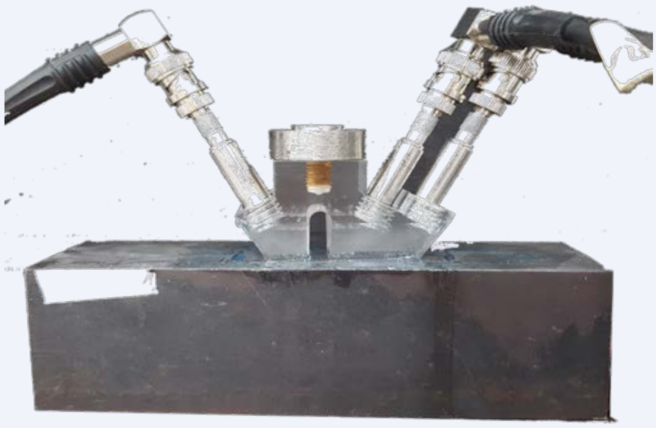
Longitudinal waves can also be used to measure the stresses acting at 90° to the material surface by placing the transmitting and receiving probes directly onto the surface in either a transmission or reflection set-up. By using shear waves however, it is possible to measure the stresses acting parallel to the material surface with a transmission or reflection set-up.

An oscilloscope is then used to record the time taken for the ultrasonic waves to travel between the transmitter and receiver/s. The Time-of-Flight of the ultrasonic waves in the stressed, *t*, and unstressed, *t0*, states are then used to calculate the relative level of stress, *Δσ*, experienced using:

$$\Delta\sigma = \frac{E(t - t0)}{L11.t0}$$

Where *L11* is the acoustoelastic coefficient of the material and *E* is the Young's Modulus. *L11* is usually determined experimentally with a tensile test.





Technique Specifications:

- Non-destructive technique;
- Laboratory or "on-site" measurements;
- Tri-axial residual stress measurements possible;
- High magnitude residual stresses are measured accurately;
- Measurement depths of up to 150mm possible;
- Applicable to a wide range of materials;
- Great for measuring applied stresses;
- Very quick measurement process;
- Requires a stress calibration measurement in order to provide absolute stress values;
- Very sensitive to microstructural changes;
- Provides an average stress measurement over a relatively large gauge volume;
- Through-thickness measurements require the component surfaces to be parallel;
- Not applicable to complex shaped components;
- Requires a good component surface finish;
- Spatial resolution is difficult to specify.