Long Range Ultrasonic Technologies

Part of TWI's Non-Destructive Testing Technology Group

TWI

WORLD CENTRE FOR MATERIALS JOINING TECHNOLOGY

Long Range Ultrasonic Technology at TWI

The Long Range Ultrasonic Technology (LRUT) Group is one of TWI's fastest growing sections. Expertise on all aspects of guided waves is available to Industrial Member companies, including choice and optimisation of technique, limits of detection, fitness for purpose assessment, and more.

Our Goal

To develop cutting edge LRU Technologies and provide customers with high quality LRU inspection solutions, through strong commitment, creative innovation and quality service.

Objectives

- To enhance the competitiveness and viability of LRUT through effective R&D, technology transfer and quality support services;
- To support customers and provide them with innovative solutions;
- To educate and train individuals in utilizing LRUT;

What is Long Range Ultrasonic Inspection?

LRUT is traditionally used to detect corrosion, erosion and other defects in pipework. An array of transducers is clamped around the pipe and ultrasound is transmitted simultaneously along the pipe in both directions. The return signal is received by the same transducers, and the data are analysed using the system's calibrated software.

The technique's principal advantage is that it provides 100% initial screening coverage, and only requires local access to the pipe surface where the transducer array is to be attached. The technique has the ability to inspect inaccessible areas such as clamps and cased or buried pipes. It works without the need to remove insulation or coating.

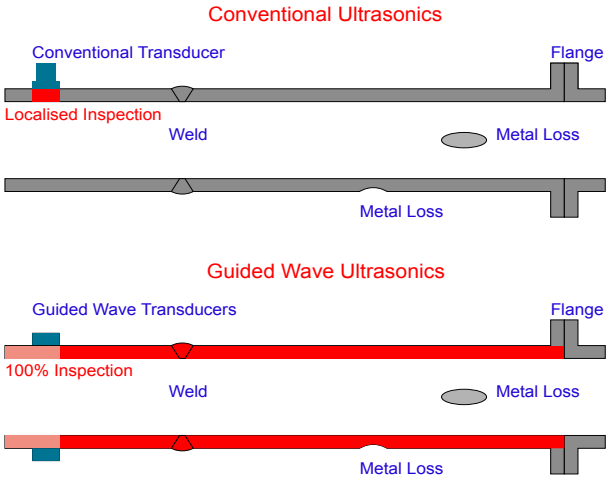
LRUT is commercially available through Plant Integrity Ltd (P*i*), part of the TWI Group. P*i* both sells and provides services with the *Teletest Focus*™ system. Recent developments have enabled the transducer array to 'focus' the ultrasound at points around the circumference of the pipe, allowing inspectors not only to identify how far down the pipe the problem lies, but also its location on the pipe circumference.

Features of *Teletest*® system include:

- Rapid screening for in-service degradation
- Avoidance of removal/reinstatement of insulation or coating, except at location of transducer tool thus reducing costs of gaining access
- Ability to inspect inaccessible areas i.e. clamps and cased or buried pipes
- 100% coverage
- Test Range ±30m (typical) and ±180m (ideal)
- Detection of internal or external metal loss

System Sensitivity

- Metal loss down to 3% of pipe wall cross- section
- Reliable detection of 5% metal loss flaws
- Discrimination between flaws and pipe features; welds, bends, supports, etc.
- Longitudinal accuracy better than ±100mm



Consultancy

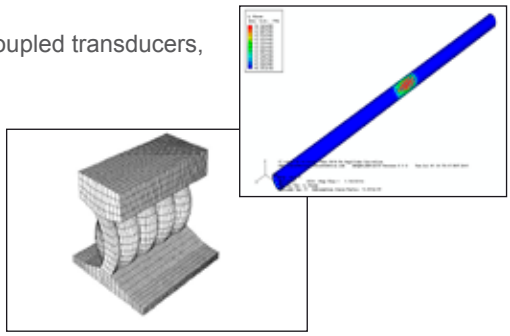
Applications

This technology has been proven for use in pipes with diameters from 1.5” to 48” . There are further applications for which the technology is being developed. These include:

- Chemical plant: heat exchangers, embedded and cased pipes
- Oil and gas: offshore structures, risers, flow lines, storage tanks
- Constructions: bridges, ropes, jetties, sheet piling
- Food and drink: pipes, heat exchangers

Technology and Expertise

- Electronics design
- Novel transducer design & development (e.g. air-coupled transducers, EMATs, etc.)
- Advanced signal processing
- Software programming
- *Teletest*® unit
- Finite element modelling
- Acoustic emission



People

TWI’s LRUT Group consists of 25 highly skilled staff competent to provide a wide range of NDT solutions, especially in guided wave techniques. Each individual is qualified with Chartered Engineering (CEng) status or progressing towards CEng, PCN level II and III. In addition, the group works with academic institutions to develop Engineering Doctorate (EngDoc) students.

Service

- R&D for member companies
- Third party consultancy
- Innovative NDT inspection solutions
- Actively involved in joint projects
- Technology Transfer
- Training and certification

Corporate Links

The LRUT Group interacts with a wide range of other global organisations, including equipment manufacturers, research organisations and end users.

Research Projects

The LRUT group is undertaking one of the largest research programmes in the world into new projects performed are either Group Sponsored (or Joint Industry) Projects, Collaborative and DTI) or part of TWI's Core Research Programme (funded by technology access fees from Indu Some of the projects included in this programme are:

RISERTEST (Total project value €2m)

Development of a LRUT System to examine Offshore Subsea Risers, Steel Catenary Risers (SCRs) and Flowlines

The development of very deep-water offshore oil fields has thrown up a number of technical difficulties in the area of Non-Destructive Testing (NDT). One of the main concerns relates to the in-service inspection of subsea risers, steel catenary risers (SCRs) and flowlines, where conventional techniques are not easily deployed.

LRUT offers a solution that will overcome the limitations of current technologies.

Some of the objectives of the RISERTEST programme are:

- *To develop the world's first technology to continuously monitor deepwater SCRs in service with the ability to detect flaws at a range of three pipe lengths in each direction from the transducer array, and transmit data to a base station without a cable connection*
- *To develop a novel LRUT technology to detect corrosion in sub-sea flowlines and fatigue cracks and corrosion in sub-sea risers and SCRs.*
- *To develop ultrasound focusing techniques to distinguish between deep narrow crack and wide shallow ones of the same cross sectional area.*

End-user participants

BP Exploration Operating Company Limited, Det Norsk Veritas, Petroleo Brasileiro S.A. (Petrobras).

Offshore platform

A Key Technology for Direct assessment of Buried Pipelines - Validation and Enhancement of Long Range Guided Wave Ultrasonic Testing (Total project value: €1m)

Building on the successes of the on-going Department of Transport (DoT, USA) project this programme addresses three areas that require additional investment in LRUT, in order to meet the demands of the industry fully. These are:

(a) Field Validation. Taking enhanced LRUT methods (phased array focusing, multi-mode and frequency sweep) from the laboratory and developing them into robust field techniques. There is a need to validate the capabilities and limitations of new tools/field techniques via field demonstrations under a variety of operational conditions.

This will result in pipeline operating companies having sufficient confidence in the results.

(b) Extending the test range and flaw discrimination capabilities in coated pipes. As the ultrasonic wave travels along a coated pipe, it propagates in a two-layer structure - the pipe material itself and the viscoelastic outer coating. By controlling the ultrasonic vibrations that are propagated in the pipe, it should be possible to minimize the power travelling at the interface between the pipe and the coating. It then becomes possible for the ultrasonic energy to travel a long distance in the pipe with minimal leakage into the coating.

c) Improving inspection capability in complex pipe work. The two approaches referred to above, namely steering the beam around an elbow so that the wave mode beyond the elbow is symmetrical, or alternatively focusing the ultrasound beyond the elbow, will both be validated.

End-user participants.

US Department of Transportation, Northeast Gas Association, Advantica (Transco), BP, ConocoPhillips.

Teletest tool on pipe in bell hole

techniques and their applications in guided waves, with a value in excess of €30 million. The Technology Transfer Projects (typically funded by public sector agencies such as the EC or ustrial Members in order to develop a knowledge and skills base for transfer into industry).

OPCOM (Total project value €3m)

Development of LRUT Technology for the Condition Monitoring of Offshore Structures

Offshore structures, such as oil production platforms and wind turbine towers require frequent inspection. Deficiencies in current methods have provided the push for the development of new technologies for offshore structure inspection.

The majority of offshore wind turbine towers are at the start of their life, whilst the offshore oil and gas platforms are at the end of their life cycle (25-40 years).

The development of LRUT technology for inspecting offshore structures has the potential to impact upon the life cycle costs of vital components of the infrastructure through:

1. *Continuous monitoring of structural integrity from fabrication to scrapping;*
2. *Extending the life of offshore structures, therefore reducing depletion of resources for new builds.*

The OPCOM programme has developed a variety of new long-range guided wave techniques to detect cracks and corrosion in offshore structures, by addressing major drawbacks in current inspection technologies New imaging and data analysis techniques have also been established.

End-user participants

Statoil AS, Elsam Engineering A/S, the UK Health and Safety Executive.

Offshore platform complex

LRUCM (Total project value €4.3m)

Long Range Ultrasonic Condition Monitoring of Engineering Assets.

The condition of Europe's engineering assets is regularly monitored to ensure continued integrity. Across the continent, the annual maintenance/inspection budget for these assets is in the region of €225 billion. Despite this, failures still occur, often with catastrophic consequences:

- *Oil/gas pipelines.*
- *Rails.*
- *Bridges.*
- *Sea/river defences.*

The development of new techniques for monitoring the condition of a range of engineering assets in the LRUCM programme is increasing the reliability of the inspections. The advent of new LRUT techniques is allowing the technology to be made available to a greater variety of industries and for a greater range of applications.

Institute / Association Participants.

Deutsche Gesellschaft fur Zerstorungsfreie Prufung EV, European Federation of Non-Destructive Testing, Asociacion Espanola de Ensayos No Destructivos, Associacao Portuguesa de Manutencao Industrial, Associazone Italiana Prove Non Distruttive Monitoraggio Diagnostica, Instituto de Soldadura e Qualidade Associacao, Ukranian Society for Non Destructive Testing and Technical Diagnostics.

Railway junctions

CHAINTEST (Total project value €2m)

Autonomous Robotic System for the Inspection of Mooring Chains that Tether Offshore Oil and Gas Structures to the Ocean Floor

A typical floating structure such as a floating production, storage and off-loading (FPSO) vessel may have as many as 14 mooring chains, which might amount to nearly 10km of chain in total. Mooring chains are subject to cyclic loads and, therefore, fatigue.

The ChainTest project is improving inspection performance, increasing the probability of detection to 90% through robotic delivery of advanced, automated ultrasonic guided wave techniques that are able to detect significant defects with minimal surface preparation. Automatic data capture, recording and analysis is improving accuracy, consistency and repeatability of results.

End-user participants.

Petroleo Brasileiro S.A. (Petrobras), Vicinay.

Inspection of chain link

TANKINSPECT (Total project value €2m)

Condition Monitoring of Large Oil and Chemical Storage Tanks using Ultrasonic Guided Wave Tomography without the Need to Empty and Clean the Tanks

Leakage from corroded storage tanks, especially their floors, is a major environmental, economic and safety hazard. External inspection is inadequate because current methods can only inspect up to 1m into the tank.

While tank shells are easily accessible for inspection, tank floors are significantly more difficult. To overcome the problems associated with tank floor inspection, the TankInspect project has developed an alternative inspection method based on LRUT techniques, whereby an array of transducers is located around the tank floor and synchronised transmissions of ultrasound allow inspectors to develop a map of the tank floor indicating any visible features such as corrosion, position of the welds and possibly weld defects.

End-user participants.

Kaneb Terminals, Total, Vopak.

Corrosion damage in tank floor

PIPESCAN (Total project value €2m)

Development of Systems for the Inspection of Metal Pipelines Buried Underground, in Concrete, in Water or Covered with Coatings.

Over 10 million kilometres of pipelines in Europe carry hazardous fluids and gases, often at high pressure and temperature. Defects may develop in these pipelines due to corrosion or fatigue. Inspection is therefore critical.

By utilising appropriate guided wave ultrasonic inspection techniques, the PIPESCAN consortium has developed mechanised inspection techniques, sensors and systems for finding defects and corrosion in inaccessible pipe without the need to excavate the area surrounding the pipe, or remove pipe coatings.

PIPESCAN utilises advanced guided wave systems using multi-wave modes to increase sensitivity under challenging conditions.

End-user participants

Kaneb Terminals, Total, the UK Health and Safety Executive.

Road crossing on the North Slope

Development of Phased Array and Swept Frequency LRUT Techniques for Fitness-for-service Assessment of Pipe Corrosion (Total project value: €0.3m)

LRUT has already established a niche for screening pipes for flaws, corrosion in particular, where access is difficult.

A new LRUT flaw detector has been developed that has phased array capability enabling ultrasound to be focused at a selected point both along and around the pipe. Furthermore this phased array capability enables ultrasound to be 'steered' around an elbow or alternatively focused at a point beyond an elbow.

This facility will begin to enable LRUT to have a partial flaw sizing capability. It will be possible to distinguish distributed shallow flaws from narrow deep ones. The steering capability will improve flaw detection capability beyond pipe bends and elbows.

Also new software has been introduced which can automatically sweep through a range of frequencies. This will enable improved performance in the presence of attenuative wrappings.

Benefits

- Enhanced LRUT. *The project is evaluating and validating an enhanced LRUT system. This system will provide:*
  - *Improved discrimination and partial flaw sizing*
  - *Ability to inspect in and beyond elbows*
- Inspection cost savings combined with increased safety. *An enhanced LRUT inspection system will confer additional cost savings over and above those already available through the use of current LRUT methods. It will also ensure increased safety since the potentially dangerous deep narrow flaws will be more readily detected.*

Ahia manifold

End-user participants.

US Department of Transportation, Northeast Gas Association, Advantica (Transco), BP, ConocoPhillips.

NDT Inspection of Inaccessible Electrical Wiring in Aging Aircraft (Total project value: €1.85m)

A modern aircraft will have about 300 miles (480km) of wiring. Defects in wiring pose one of the greatest risks to an aircraft's integrity. As aircraft age, the wiring systems become increasingly prone to various types of failure. Rewiring in aircraft is very expensive. Unless the wiring's life can be extended, there may be no alternative to the permanent withdrawal of the aircraft from service. This project aims to develop an innovative combination of complementary NDT techniques to provide 100% inspection coverage of all of an aircraft's wiring. The techniques will be:

- *Enhanced time domain rellectometry. A technique permitting the remote inspection of wire pairs running the entire length of the aircraft.*
- *Guided wave ultrasonics (LRUT) with the innovative potential to inspect every wire (both the insulator and the conductor) in a wire bundle.*
- *A combination of Pulsed Arrested Spark Discharge (PASD) and thermographic detection of PASD induced temperature profile (PASD-T).*

Inspection of aircraft

End-user participants.

British Airways, Airbus, BAe Systems, Civil Aviation Authority.

LRUT in the Food Processing Industry (Total project value: €1.85m)

In a typical food or drinks processing plant there are over 500 pipelines. There are also numerous heat exchangers with associated piping. The pipes in these systems are susceptible to corrosion, erosion, cracking and fouling. Furthermore, they are frequently inaccessible for inspection by conventional non-destructive testing (NDT) methods. Failures and/or blockages can occur and these are very expensive, particularly when the cost of plant downtime is taken into account. This project is aimed at taking the LRUT system already developed for applications in the oil, gas and chemical industries and developing it for use on the smaller diameter pipes to be found in a food processing plant.

End-user participants.

Cadbury Trebor Bassett, Heinz, Coors Brewers and British Salt.

Plate type heat exchanger sterilising system

In-situ Wireless Monitoring of Offshore Wind Towers and Blades (Total project value: €3.2m)

The project will Research, Develop and Demonstrate (RD&D) an advanced system for real-time condition monitoring and impending failure detection for the turbine blades and towers of offshore wind power facilities. The system will provide structural health monitoring with 100% volume coverage to enable design life to be realised and to avoid expensive and premature replacements and repair of wind power assets.

The composite blades can suffer fatigue failure and towers are susceptible to corrosion and fatigue. Blades and structures require regular inspection to avoid catastrophic failure risk. Current inspection methods can only be performed offline, through human intervention, with limited volume coverage and are cumbersome, time consuming, hazardous and expensive. The project will develop novel technology to monitor offshore wind tower structures above and below sea level & turbine blades continuously, using embedded inductive displacement sensors (IDS) and long range ultrasonic (LRU) and acoustic emission technique (AE) in combination (LRU/AE). Data will be transmitted and the system controlled by wireless links with the shore base.

End-user participants

Scottish Power, RWE npower, TUV NEL Ltd, CAN Offshore Ltd, Fugro GEOS, BT

Damaged wind turbine blades

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