Industrial Doctorate Centre in Non-destructive Evaluation (NDE)

Developing NDE technologies and training engineers for the 21st century

What is NDE?

Inspection technology for integrity assessment

NDE uses non-invasive techniques to determine the integrity of a material, component or structure – or to measure some characteristic of an object. It is a key enabling capability for advanced manufacturing and plant operation across a wide range of industry sectors which:

- ensures the safety of structures, machinery and infrastructure
- minimises environmental risks and impacts of process plant and operations
- enhances the reliability of components, equipment, systems and products.

Inspection technology involves the use of a range of modalities such as ultrasonic, radiographic, optical, magnetic and electrical techniques. Application of these techniques ranges from simple manual inspection to highly automated deployment with sophisticated sensors, image and data analysis systems.

The IDC research programme

Developing novel NDE technologies

The Industrial Doctorate Centre in NDE is operated by a consortium of five universities and is supported through a Strategic Partnership between EPSRC and the industrial members of the UK Research Centre in NDE (RCNDE). Industrial partners also include suppliers of new NDE technology.

The Centre enables graduates to study for an EngD or PhD whilst working at some of the UK's leading companies. The research programme covers all branches of NDE and all projects must have the potential for significant industrial impact.

Priority themes include modelling, reliability, automation, defect characterisation, sensor technology, structural health monitoring, and the challenges of advanced materials and difficult access. Where possible the projects integrate NDE into materials engineering and structural performance.

Students also undertake a range of technical courses and learn business skills such as marketing and financial management.

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2D ultrasonic array system for the in-situ inspection of single crystal turbine blades

Christopher Lane
Rolls-Royce,
Bristol University

EngD project example

Two-dimensional (2D) ultrasonic arrays for non-destructive evaluation enable the detection and characterisation of sub-surface defects in three-dimensions (3D).

One potential industrial application for this technology is the in-situ inspection of jet-engine turbine blades for root cracking. However modern jet-engine turbine blades are cast from single crystals of nickel-based superalloys because of their excellent mechanical properties at high temperature. Single-crystal materials are elastically anisotropic, which causes ultrasonic waves to propagate with different velocities depending on the direction of the wave and which significantly reduces the quality of the inspection.

This project involved the use of wave propagation modelling to correct ultrasonic imaging algorithms and enable the reliable volumetric inspection of single-crystal aerospace components. It also found ways to overcome physical access constraints for in-situ inspection and evaluated defect detection sensitivity and sizing capability.

Orientation of the crystal in a turbine blade

Drawing of engine probe on the turbine blade

Typical data display

The Engineering Doctorate for NDE

- *World-class research to deliver new inspection solutions meeting industry needs*
- *A route for technology transfer to embed new methods into company products or processes*
- *Providing high-calibre recruits into the engineering community*

Thermography for power station environments

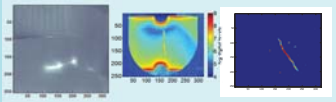
Ben Weekes
RWE, Imperial & Bath University

EngD project example

Power-plants of the 1960's are currently being decommissioned, and their replacements need new inspection methods. Recent advances in the inspection of metals by thermal NDE have made these methods widely applicable in the inspection of typical power plant components such as turbine blades.

Active thermal NDE offers a fast and adaptable inspection, with excitation of the part typically performed by (but not limited to) high-power ultrasound, optically (such as by laser), or by electromagnetic pulses. One of the main attractions of thermal methods is that they are simpler to apply to complex geometries than, for example, ultrasound.

This project has developed specific inspections with new thermal methods and evaluated performance, with the aim of speeding up inspections and reducing the use of conventional penetrant inspection.



Thermographic images of different cracks using (a) thermosonics (b) eddy current induction and (c) laser spot heat sources

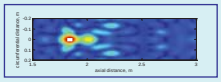
Guided waves for power plant applications

Sam Fletcher
E.ON, Imperial College

EngD project example

The aim of the project was to locate and size axially aligned cracking in cold-form bends using guided waves. Cold-form bends are prevalent in power stations, and a typical large power station might have a few thousand. Once it was realised they were vulnerable an industry-wide program was started to locate axial cracking using conventional NDT techniques. This is a very laborious process and some of the pipes are in inaccessible locations making them difficult to inspect using traditional methods that only interrogate the area in the immediate vicinity of the inspection site.

Guided waves are sound waves that can travel long distances guided by a structure such as a pipe. Guided waves are already commonly used by the oil and gas industry to locate corrosion; however, because they are sensitive to cross-sectional wall loss in a pipe, guided waves are not sensitive to axial cracks (which have a very low cross sectional loss). Techniques such as guided wave focusing are being investigated to determine whether it is possible to find such defects using guided waves and provide a screening system that can be used to target traditional NDE methods more effectively.



Unrolled pipe display generated using a focusing algorithm

NDE to reduce defect-related failures in turbocharger turbine wheels

Sean Winwood,
Cummins Turbo Technologies,
Warwick University

EngD project example

The challenge was to develop a reliable technique for inspecting difficult-to-reach parts near the blade root of turbocharger turbine wheels, which are manufactured by investment casting of a nickel-based superalloy.

Inspection also had to deal with small variations in the distance between adjacent blades. The answer was to develop a conformable array of miniature eddy current sensors using micro stereolithography (MSL) techniques from Warwick University.

The approach is intended for use in monitoring supplier quality and allowing Cummins to work with its suppliers to refine their casting processes.

Turbine wheel

Examples of conformable eddy current arrays

Use of microwaves for the detection of Corrosion Under Insulation (CUI)

Robin Jones
BP, Imperial College

EngD project example

Corrosion Under Insulation (CUI) is a significant cause of pipeline failure in the oil and gas industry. When water breaches the external cladding used to protect the insulation, it allows corrosion of the external pipe surface to initiate.

Inspection of the pipe by removal of the insulation is expensive and time consuming, and the majority of techniques capable of non-invasively inspecting for CUI can only inspect small areas at a time which renders them impractical for the inspection of the miles of pipeline typically found at a facility.

This project explored the possibility of detecting the presence of water within the insulation, a necessary precursor to CUI. In particular, the pipe and the cladding can form a coaxial waveguide which can be used to propagate microwaves within the insulation along the length of the pipe. Since water has a relative permittivity much higher than that of the surrounding insulation, any patches of water along the pipeline will give rise to a strong reflection of the incident microwave signal, providing a method to detect and locate the water patches.

UK Research Centre in Non-Destructive Evaluation

Industries of the 21st century face ever more challenging requirements to achieve greater integrity and safety performance and adopt new materials and designs. Novel NDE technologies are often crucial to making this possible.

The IDC is linked to the UK Research Centre in NDE (RCNDE), an EPSRC-sponsored partnership between industry and academia to coordinate research into NDE technologies and to ensure research topics make a significant impact upon the longer-term needs of industry. Industrial and academic members together select longer-term core research topics, which are aimed at addressing industry's strategic NDE needs over a 10 to 20-year horizon, and also targeted research projects to address specific industrial needs in the medium term.

There are currently 16 industrial member companies representing power generation, oil & gas, aerospace, defence, nuclear, transport and manufacturing sectors. The NDE supply chain is a vital element for successfully transferring technological advances arising from university research to their eventual practical application in industry. To this end, the Centre involves all parts of the NDE supply chain through an Associate Membership scheme, including SMEs and organisations offering training, consultancy, field services and hardware.

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