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NATIONAL NUCLEAR LABORATORY

RCNDE News

Research Centre for Non Destructive Evaluation

Welcome to Issue 14 of the NNL RCNDE Newsletter which is distributed to NNL's RCNDE network across the NDA estate. NNL is a proud member of the Research Centre for Non Destructive Evaluation (RCNDE) on behalf of the NDA.

The RCNDE, formed in 2003, is an EPSRC (Engineering and Physical Sciences Research Council) sponsored collaboration between industry and academia to coordinate research into NDE technologies and to ensure research topics are relevant to the medium and longer-term needs of industry.

Funding was secured in 2014 to continue RCNDE for a further six year period covering 2014 to 2020.

More information on the RCNDE is available at www.rcnde.ac.uk.

Inside this issue

Core Research: Enhanced Imaging

RCNDE embarked on its third phase of long-term core research in April 2014, which will run until 2020. This programme is co-funded by EPSRC and by industrial members. The core research programme is structured into the following four themes:

- Enhanced imaging
- Accurate characterisation
- New technologies
- Permanent monitoring technology

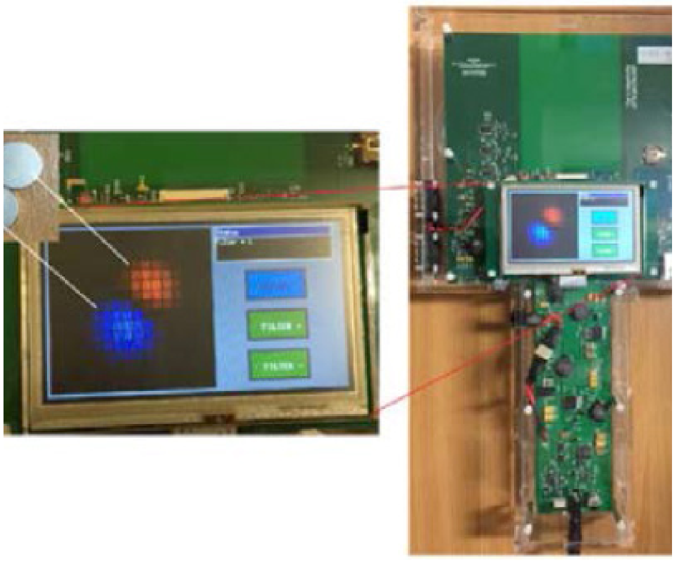
Huge progress has been made in recent years in developing imaging concepts and algorithms, enabled by the increasing availability and reducing costs of computing power, data storage and imaging hardware. The Enhanced Imaging theme was set up to pursue this progress for NDE in some key directions that have been identified to address the vision of the RCNDE industrial members. The research work addresses two fundamental goals:

- Improve the reliability of detecting defects, by achieving better coverage where access is limited and bringing automation, improved interpretation and permanent objective recording to techniques that currently rely on manual deployment and reporting.
- Improve the efficiency of imaging by reducing the quantity of data and instrumentation needed for measurement acquisitions, and the interpretation time for skilled inspectors.

One project forming part of the Enhanced Imaging research theme 1 is at the University of Manchester aiming to develop a novel prototype Magnetic Camera and assess its performance for Magnetic Flux Leakage (MFL) NDE detection.

MFL and Eddy Current testing (ECT) are widely used in various industries. However, many existing ECT techniques use wire coils for magnetic field sensors which have drawbacks such as poor portability due to large size, slow scanning speeds, low spatial resolution and complicated mechanical structures required for automated testing systems. For MFL, these issues are circumvented to some extent using conventional Hall Effect sensors using either silicon or GaAs elements. These work well down to DC but are limited in their sensitivities.

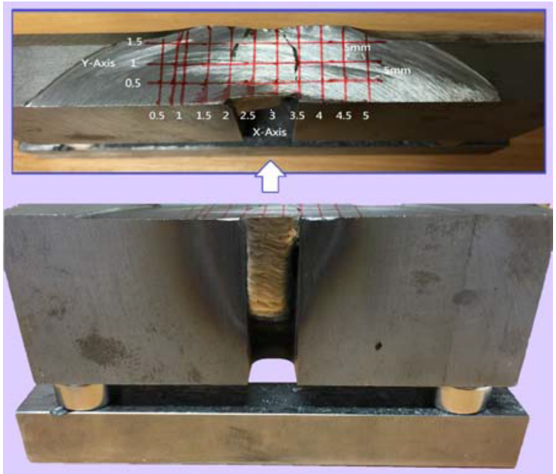
MFL techniques have gained momentum due to recent improvements in sensor technology to detect magnetic fields as small as nano-Tesla. As the MFL technique relies on the sensitivity of the sensors it uses, these advanced sensors can revolutionise the method of detecting defects and flaws at and under the surface, not only for magnetic but also for nonmagnetic materials.



Photograph of the 16 x 16 QWHE Array Magnetic Camera with inset showing the result of measuring two magnets with different poles

New micro sensors developed at the University of Manchester, called Quantum Well Hall Effect (QWHE) sensors, use high-mobility semiconductors which supersede and overcome many of the disadvantages of conventional Hall Effect sensors, including orders of magnitude higher resolution, down to a detection limit of ≤1nT, size <10 μm and frequency response from DC to GHz.

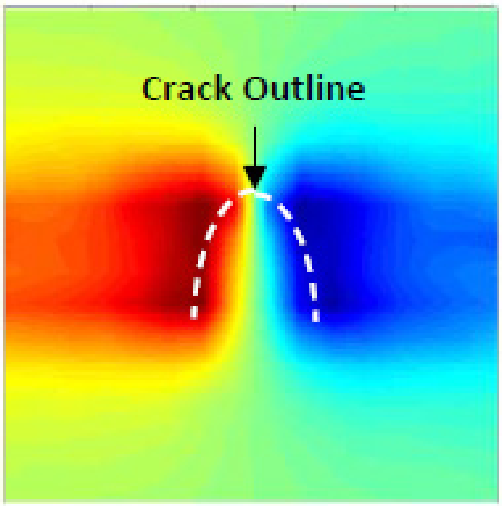
Advanced 2D QWHE devices are the building blocks of the magnetic camera which is at the heart of this project. A prototype magnetic camera with 16 x 16 array of QWHE sensors has been constructed and is capable of reproducing an image of the leaked magnetic flux.



NNUMAN weld sample with crack

In ECT, the material under investigation is illuminated with an alternating magnetic field generated by an external coil from one side of the surface. In the presence of a discontinuity (eg a flaw) in the test material, the induced eddy current is disturbed leading to a variation in the magnetic field compared to that without any discontinuity. This is a common means of detecting near-surface defects. However, if the defect or flaw is deep within the material, then it is difficult to use this technique due to its inherent disadvantage resulting from the skin effect, which confines the induced alternating current at higher frequencies to the near surface region of the conductor.

A real NDT welding crack sample was obtained from the New Nuclear Manufacturing (NNUMAN) project team at the University of Manchester. The experimental set up used the sample as the top rectangular plate with the welded site running vertically through its middle, biased by two magnets, with a bottom plate as the field sink. The presence of the crack defect is clearly detected by the magnetic camera as shown in the colour map of the magnetic field distribution in the vicinity of the crack.



Magnetic field distribution of NNUMAN weld sample with crack defect

Remote Visual Inspection of Pipework

Mosaicing for Automatic Pipe Scanning (MAPS) is a 3-year Innovate UK funded Collaborative Research and Development project to develop a system combining optical hardware and advanced image processing techniques for interactive 3D Remote Visual Inspection (RVI) of pipe work in the nuclear industry. The consortium comprises Inspectahire, University of Strathclyde, Wideblue Ltd, Sellafield Ltd and is led by the National Nuclear Laboratory.

The project started in April 2015 and progress to date has focused on development of prototype hardware and software to meet a user requirement specification developed by NNL and SL. The probe hardware incorporates a wide field of view machine vison camera, coupled with a structured light laser line projector, an inertial measurement system and illumination housed in a robust enclosure aimed at 2-4 inch pipes. High accuracy measurements of cross sectional geometry acquired from the laser subsystem are used to form a 3D CAD model of the interior geometry of the pipe. The signal processing employs feature extraction and inertial measurements to estimate the 3D position of the probe and overlays the visual images onto the CAD model of the pipe to enable key measurements of the pipe and defect geometries. The image processing builds on several years of RCNDE research from the University of Strathclyde.

An initial prototype has been constructed and tested on pipework supplied by NNL. Preliminary results have been promising and a second prototype has been designed and is currently under construction.

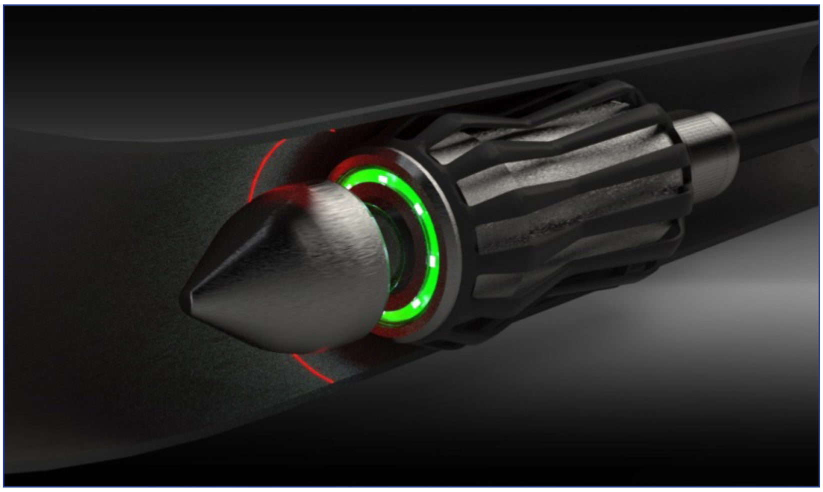


Illustration of MAPS prototype currently under construction

The project partners have been shortlisted for the Scottish Knowledge Exchange Awards 2017. The Multi-Party Collaboration Award is open to groups and consortia involving three or more parties working together on an innovative research project which includes a research partner from Scottish academia and at least one business.

RCNDE Industrial Members' Vision for NDE

RCNDE industrial members are collectively represented by a not-for-profit company, NDE Research Association (NDEvR), which manages the affairs of RCNDE. In 2010, NDEvR agreed a strategic partnership with EPSRC. This was renewed in 2014 for 5 more years, with the purpose of furthering longer-term NDE research and refreshing and building the UK NDE research skills base. This reflected the recognition that NDE is an essential enabling technology to help with company and national goals for industrial growth. Therefore, an important task for NDEvR members is to prepare a collective view of the future requirements for NDE in their respective industry sectors (including nuclear), and more specifically at 5, 10 and 20-year horizons. This process was first performed in 2011 and is currently being repeated with input into the nuclear vision from AMEC FW, EDF Energy, Hitachi Europe, NNL and Sellafield Ltd.

The exercise considered individual industry sector trends, technological possibilities, emerging innovations and future sector and company needs. This review was undertaken in the context of a broad range of drivers, including market, regulatory, safety, environmental and economic factors.

The members considered near, medium and long-term horizons mapped to 5, 10 and 20 years into the future. For setting the 5-year vision, the group was asked to consider what had been state-of-the-art five years ago, what has changed since and what may represent the future application of known emerging technologies and solutions. By matching the requirements of each company's near-term business planning and knowledge of current pioneering technologies (for example those currently at TRL3 were deemed to be good candidates), the 5-year vision seeks to establish what the business needs for NDE will be over this period.

In contrast, the 10-year vision drew heavily on 'next generation' technologies. Defining business needs in NDE terms requires an understanding of where the individual businesses expect to be in 10 years' time and involves consultation with colleagues within members' organisations regarding the use of NDE data and any perceived limitations. The scoping of technologies potentially able to meet these future needs is somewhat more speculative. Indeed, the vision relates to current or planned research activities, including those presently at TRL1-2. Therefore, development paths are broadly apparent today, albeit with some imagination.

The 20-year visions are much more speculative and explore new ideas without hindrance from the current knowledge of capability. Members were asked to consider the 'can't do' areas of NDE, including tasks where NDE is not used or envisaged, for example where the prevailing alternative is to scrap, strip or replace. Unavoidable practices and methodologies were challenged as possibly fruitful game-changing uses of NDE, such as discarding parts with potentially useful remaining lives. The 20-year visions assume advances in all supportive technologies, and envisage that the required understanding will exist for all facets of the engineering problems for which an NDE detection or measurement capability might be relevant. This is a distant horizon and some goals are specific and others conceptual.

The outputs from this vision exercise can be used in a variety of ways. The original output from 2011 was important in shaping the current (2014-2020) RCNDE core research programme as it identified themes of broad interest to multiple members. Other themes have led to collaborations amongst industrial members as elective research projects. The various sector visions are currently under review and will be available by April 2017.

Future Events and Further information

9 May 2017, Centre for Doctoral Training Review Day, Bristol

10 May 2017, RCNDE Core Research Review Day, Bristol

11 May 2017, RCNDE Board Meeting, Bristol

4 September 2017, RCNDE Board Meeting, Telford

5-7 September 2017, BINDT Annual Conference and Materials Testing Exhibition, Telford

For back issues of the RCNDE newsletter, please visit www.nnl.co.uk/rcnde. If you require further information on any of the articles in this newsletter or any aspect of the RCNDE please contact:

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