Institution: BRUNEL UNIVERSITY (H0113)

Unit of Assessment: 15 – General Engineering

Title of case study: National Structural Integrity Research Centre (NSIRC)

1. Summary of the impact (indicative maximum 100 words)

Brunel and The Welding Institute (TWI) have been pursuing collaborative research on the use of ultrasonic guided waves for the non-destructive testing of oil & gas pipelines, plates, rails, aircraft wires and other engineering materials since 2003. This successful collaboration has led to the creation in 2009 of the Brunel Innovation Centre (BIC), a joint venture between the two institutions based at TWI headquarters in Great Abington, Cambridgeshire, whose mission is to develop a financially sustainable research facility, drawing on Brunel's existing strengths, to complement and underpin the applied research and development activities at TWI. BIC's very successful operation has led TWI to make a significant re-alignment of their strategy and business model, from being a technology provider offering mostly short-term industrial research and consultancy to their members, to providing medium- and long-term research and postgraduate training at the new National Structural Integrity Research Centre (NSIRC), a joint facility being built at TWI headquarters. TWI received a grant of £22 million from the Regional Growth Fund to fund the new building, complemented by a £10 million investment from their own resources and a £15m HEFCE grant for equipment. NSIRC will become a world-class centre of excellence with a unique, industry-driven, integrated approach to research and postgraduate training in the field of structural integrity.

2. Underpinning research (indicative maximum 500 words)

Brunel University started its collaboration with TWI in 2003, by placing students from Brunel's Engineering Doctorate in Environmental Technology to pursue research in ultrasonic guided waves for oil & gas pipeline inspection, plates, rails and aircraft wires. Five EngD students were placed at TWI between 2003 and 2010, all supervised by Professor Balachandran. All EngD students were awarded their degrees for research which contributed to advancing knowledge on the development and application of ultrasonic guided waves to non-destructive testing (NDT) [1-5].

Brunel and TWI also signed a bi-lateral agreement in 2009 to co-fund five new PhD students, all based at TWI, followed by another agreement in 2011 to co-fund a further eleven PhD students under TWI's Core Research Programme. The sixteen PhD students are working on different areas of NDT and structural integrity research, such as broadband eddy current system for detection of corrosion under insulation, guided waves for coated/insulated structures, development of continuous real-time structural health monitoring, defect sizing in pipelines using higher-order guided ultrasonic waves, generating fundamental knowledge with commercialisation potential. Zlatev's research on viscoelastic coatings for pipelines, supervised by Kirby, demonstrated that these coatings dissipate sound energy travelling along the pipe, attenuating both the incident and reflected signals and making responses from defects difficult to detect. The findings provide a means of quantifying those problems commonly encountered with the use of long range ultrasonic testing on coated pipes in the field [6,7], and will be used for the improved capture of the scattering from non-axisymmetric defects in coated pipes.

Based on the previous successful collaborations, Brunel and TWI decided to establish a joint venture, the Brunel Innovation Centre (BIC), based at TWI headquarters in Cambridge, in order to further extend their research collaborations. BIC aims to attract outstanding individuals and focuses on NDT and allied technologies covering a range of materials, sensors, electronics and software systems. The current BIC staff comprise the academic director (Professor Gan), 2 managers, 5 research fellows, 5 research assistants, supported by 2 administrators and 13 project technical assistants. BIC has already been awarded 20 EU projects related to several aspects and applications of NDT. Examples are HotScan, which deals with the development of a long range ultrasonic system with high temperature capability for continuous in-service inspection and structural health monitoring of steam pipes in power generation plants; novel high temperature transducers have been designed, manufactured and implemented in a new inspection and monitoring tool [8]; AutoInspect, that aims at developing a digital radiographic system for on-line inspection of powder metallurgy components in the sintered state. This technique allows fast inspection and application of image processing for the detection of small cracks, flaws and density variations in-situ, and will improve the quality of output batches by reducing scrap to the greatest

possible extent [9]; CMSWind, which developed the first extensive condition monitoring investigation on an in-service wind turbine and identified the main contributors to wind turbine maintenance costs [10].

3. References to the research (indicative maximum of six references)

[1] Mallett R, Signal Processing and Electronic Design for Non-Destructive Testing, EngD Thesis, Brunel University, 2007.

[2] Catton P, The Use of Ultrasonic Guided Waves for the In-Situ Inspection of Industrial Pipelines for Corrosion Damage, EngD Thesis, Brunel University, 2008.

[3] Gharaibeh Y, The Application of Guided Waves for Non-Destructive Examination of Complex Structures, EngD Thesis, Brunel University, 2011.

[4] Haig A, Development of Ultrasonic Guided Wave Inspection Technology for the Condition Monitoring of Offshore Structures, EngD Thesis, Brunel University, 2012.

[5] Parthipan T, Electronic System Modelling of UT Pulser-Receiver and the Electron Beam Welding Power Source, EngD Thesis, Brunel University, 2013 (submitted).

[6] Kirby R, Zlatev Z, Mudge P, On the scattering of torsional elastic waves from axisymmetric defects in coated pipes, *Journal of Sound and Vibration*, 331 (17): 3989-4004, 2012. http://dx.doi.org/10.1016/j.jsv.2012.04.013

[7] Kirby R, Zlatev Z, Mudge P, On the scattering of longitudinal elastic waves from axisymmetric defects in coated pipes, *Journal of Sound and Vibration*, 332 (20): 5040-5058, 2013. http://dx.doi.org/10.1016/j.jsv.2013.04.039

[8] Mohimi A, Richardson P, Catton P, Gan T, Balachandran W, Selcuk C, High temperature dielectric, elastic and piezoelectric coefficients of shear type Lithium Niobate crystals, *Key Engineering Materials*, Vol. 543, 117-120, 2013.
http://dx.doi.org/10.4028/www.scientific.net/KEM.543.117

[9] Ponomarev M, Kappatos V, Selcuk C, Gan T, Amos M, Halai H, Gierl C, Iovea M, Digital radiographic inspection technique for production friendly quality assessment of powder metallurgy parts, *Powder Metallurgy*, 56 (2): 92-95, 2013.
http://dx.doi.org/10.1179/0032589913Z.000000000103

[10] Soua S, Van Lieshout P, Perera A, Gan T-H, Bridge B, Determination of the combined vibrational and acoustic emission signature of a wind turbine gearbox and generator shaft in service as a pre-requisite for effective condition monitoring, Renewable Energy, Vol. 51, 175-181, 2013. http://dx.doi.org/10.1016/j.renene.2012.07.004

[11] EU Joint Project HotScan (www.hotscan.eu)

[12] EU Joint Project AutoInspect (www.autoinspectproject.eu)

[13] EU Joint Project CMSWind (www.cmswind.eu)

4. Details of the impact (indicative maximum 750 words)

Since its inception in 2009, BIC has attracted 9.2 million euros of external research funding from the EU, and over £1.3 million from EPSRC and TSB. BIC's projects normally involve multi-national and multi-partner consortia with SMEs, academic institutions and end users. The end-user beneficiaries of these projects include more than 50 large and small, UK and international industrial companies such as Airbus, Doosan Babcock, Network Rail, Jackweld Ltd, H.J. Heinz, Romax Technology, Transense, Intrinsiq Materials, Lloyd's Register, and many others. It is worth noting that TWI and Plant Integrity Ltd, TWI's commercial arm, participate in a number of these projects which are led by Brunel, providing further opportunities for commercial exploitation. Further

information can be found via the BIC website: www.brunel.ac.uk/bic.

The experience of co-managing the establishment of large research facilities, co-delivery of research programmes and co-supervision of postgraduate students led to exploratory discussions between Brunel and TWI in 2011 about the formation of a large scale postgraduate campus at TWI headquarters in Granta Park, Cambridge, aligned to the identified needs of the UK industry for enhanced techniques, technology and staff qualified in the field of structural integrity of large plants. Further impetus to these discussions was provided by the invitation from David Willets through the UKRPIF call for proposals to develop a new type of university with a focus on science, technology and postgraduates.

NSIRC's vision is to become a world-class centre of excellence with a unique, integrated approach to research and postgraduate training in the field of structural integrity (www.nsirc.co.uk). This will be achieved through advancing fundamental science, developing innovative technologies, optimising the manufacturing chain, conducting holistic product design, and demonstrating solutions for long term asset management including condition monitoring, prognostics and structural health management, across a variety of important industrial sectors through user-led applications, informed by the needs of industry. The objectives are: to develop novel postgraduate programmes (PhD and MSc) to train the next generation of researchers and engineers to support the UK science and innovation; to accelerate the translation of science into commercially relevant products and services: to contribute to the development of effective standards and regulations, and to become the research provider of choice for industry in the area of structural integrity. The key outputs arising are industry-ready engineers and scientists in structural integrity disciplines such as innovative, world-leading research on fail-safe design, flaw evaluation, corrosion prevention and structural health monitoring. The NSIRC commitment is that, by 2020, the centre will have trained around 200 PhD students carrying out research of direct interest to our industrial partners and 200 MSc students in the field of structural integrity and related issues.

The economic impact of the Brunel/TWI collaboration is evidenced by the investment raised from a UK agency (the Regional Growth Fund) for this new TWI activity, the re-alignment of TWI's core business from technology provision and consultancy to research and postgraduate training, and the re-allocation of TWI's corporate budget to fund the new research centre, which will be housed in a purpose-designed, 150,000 square foot building with state of the art laboratories, workshops and lecture facilities. In addition, a pool of industrial companies, led by TWI and including BP, Lloyd's Register, National Rail and possibly other member companies, will contribute a further £4.5 million per year for a period of 10 years, underwritten by TWI, which consists of a substantial re-allocation of TWI's corporate budget. NSIRC will advance underpinning fundamental science for the safe operation of products and structures, develop innovative, fit for purpose technologies and design rules and will demonstrate solutions for long-term asset management. This will include structural health, condition monitoring and health management through user-led applications.

Hence, the results of the Brunel/TWI long-term collaborative research on the use of ultrasonic guided waves for the non-destructive testing have supported the creation of the National Structural Integrity Research Centre. Brunel has successfully developed an academic environment which combines the benefits of a rigorous research training programme located within a challenging commercial setting, providing students with exciting opportunities to further their research experience.

NSIRC will unlock the design potential of new materials, products and structures for whole-life performance, while safeguarding end-users and operators from the disasters that have frequently accompanied technological advance in the past. It will also make a direct and important contribution to the continued economic and safe operation of existing plant, products and infrastructure, through improved maintenance and life extension. The latter is particularly important in view of the increasing pressures on energy supply and transport systems. This integrated and collaborative focus is genuinely interdisciplinary and unique amongst current academic establishments worldwide.
NSIRC represents a truly innovative public-private/universities-RTO-industry partnership in a

research field in which the UK has maintained world leadership over the last 50 years, with the consequent benefit to the UK economy.

5. Sources to corroborate the impact (indicative maximum of 10 references)

Chief Executive Officer, The Welding Institute Ltd.
Director of Technology, The Welding Institute Ltd