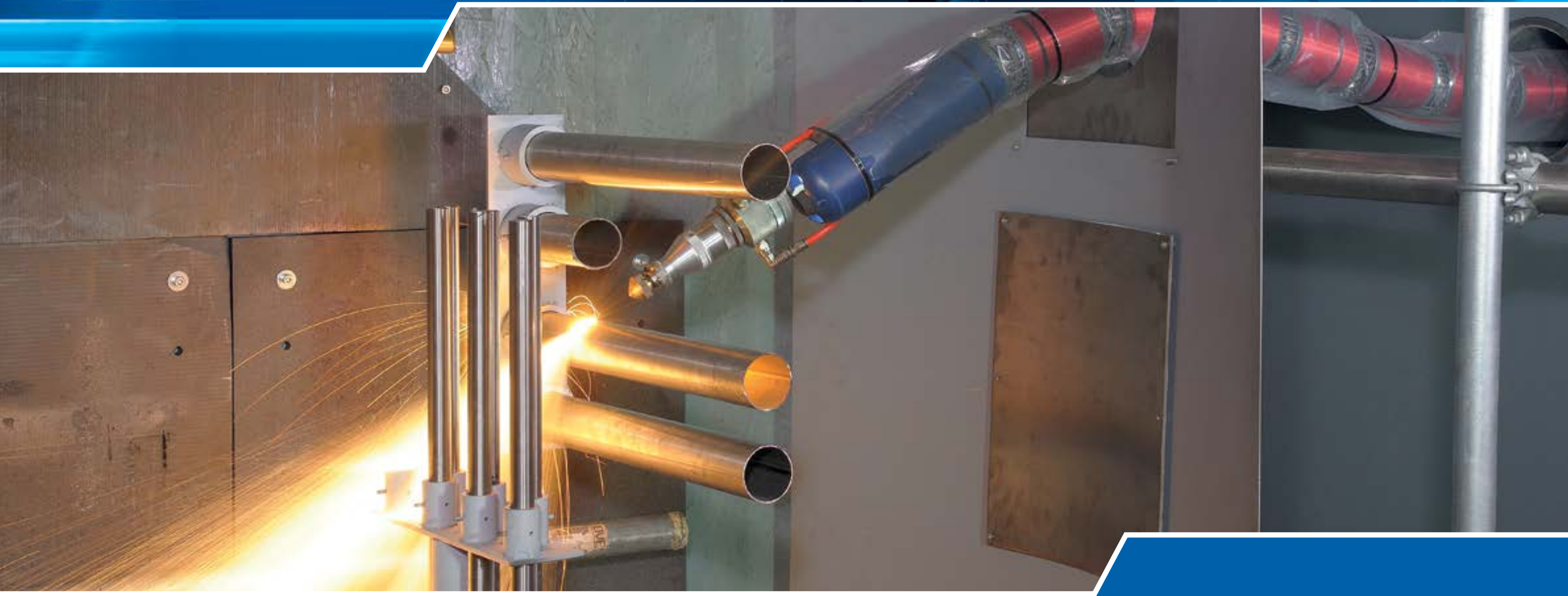
TWI

Connect+
The magazine of TWI



TWI 2016 Events

JOINOX – Guidelines for use of welded stainless steel in corrosive environments

Laser cutting as a tool for decommissioning

11th International Friction Stir Welding Symposium

Welding Institute Annual Conference

NSIRC Annual Conference

Eighth International TWI/EWI Seminar on Joining of Aerospace Materials

Find out more at: www.twi-global.com/news-events

Connect+ is the electronic newsletter from TWI. This regular e-mail publication showcases a selection of news and technical information but for an expanded view and access to a wider collection of recent papers, please visit our Connect+ webpage: www.twi-global.com/news-events/connect-plus/

TWI lands NDA innovation award for cutting-edge approach to decommissioning of nuclear skips

TWI's laser experts have been recognised by the UK Nuclear Decommissioning Authority with a prestigious award for the successful introduction of a new technology to decommission radioactive metal storage containers. The team developed a remote cutting system – utilising TWI's laser cutting technology – over a two-year period, culminating in full trials at Hinkley Point A. The new approach is expected to bring savings to the UK of hundreds of millions of pounds.

Magnox Ltd has a large number of radioactive metal storage containers which have been used over many years for storing and moving fuel elements for the UK's Magnox reactors. Currently, the cost of storing low- and intermediate-level nuclear waste is related to the volume of the parts. The estimated cost of storing one such container for its lifetime is £0.5 million. There are around 300 such containers at Hinkley Point and upwards of 2000 at Sellafield.

Although laser cutting is a well-established method for precision cutting of metals, it has only recently been applied to decommissioning. Magnox Ltd wanted to investigate an approach for breaking down metal storage containers – also known as nuclear skips – which would result in a significant reduction in the amount of active material needing storage. Notably, radioactivity in these skips is restricted to within 1.5mm of the material surface.

TWI was able to demonstrate that by using robotics to address positioning tolerances, its remote one-pass laser cutting technology can be used to quickly and safely divide a Magnox nuclear skip into five pieces. From here the pieces pass into a five-axis milling machine, their geometries are scanned and 1.5mm cut away from exposed surfaces.

The NDA Supply Chain Awards took place on 4 November 2015 in Manchester, in front of 1800 guests. The Technology/Innovation Implementation Award recognises both the innovation and collaboration required to take a technology/innovation through to successful deployment on a site. TWI accepted the award alongside Fanuc Robotics and Magnox Ltd.

For more information, please see our laser decommissioning capabilities pages or visit our homepage at www.twi-global.com.

TWI welcomes on board two Chinese technical institutes

TWI has hosted senior delegations from two state-owned Chinese technical institutes, who are among the latest organisations to join the company as Industrial Members.

The first group of delegates, from the Shanghai Institute of Special Equipment Inspection and Technology (SSEI), came to TWI's Great Abington headquarters on 14 September. SSEI carries out inspection, testing and certification of pressure vessels, boilers, pressure piping, lifts and cranes. TWI will support the company through the provision of expertise and services relating to non-destructive testing, inspection, materials and structure assessment, and training.

SSEI Chief Executive, Professor Wenhua Shu, signed the institute's membership agreement with TWI Chief Executive, Dr Christoph Wiesner. Prof Shu said that SSEI was privileged to be working with TWI and looking forward to future collaboration, while Dr Wiesner emphasised the importance of TWI's activities in China, and pledged to continue to support Chinese industry through its work.

The second delegation came from the Southwest Institute of Technique and Engineering (SITE), a research institute based in Chongqing, China, that specialises in new materials development, surfacing and corrosion management for automotive, renewable energy and marine applications.

The delegation's attendance, on 19 September, was originally just for a general visit, but the organisation was sufficiently impressed with TWI's facilities to decide to become an Industrial Member on the day. SITE Chief Executive, Mr Hulin Wu, signed the membership agreement with TWI Director of Research, Dr Paul Woollin.

TWI counts a number of Chinese companies among its Membership and continues to grow its activities in the region. It has an office in Beijing, and last year launched a Mandarin website at www.twichina.com.

New Members of TWI

GasSecure AS Norway Wireless optical gas detectors	GHD Cambridge United Kingdom Hair care products	Henderson Engineering (NE) Ltd United Kingdom Bespoke steel and aluminium fabrications	Kostal Ireland GmbH Republic of Ireland Electrical and electronic systems for auto and industrial applications
MCAAA Ltd United Kingdom Insulated power and heating cables	McElroy Manufacturing Inc. United Kingdom Heat fusion equipment for polyethylene pipe	Mercedes-Benz Grand Prix Ltd United Kingdom Formula One Racing	Mitsubishi Heavy Industries – Space Systems Division Japan Space technologies
NN Netherlands BV Netherlands Balls, rollers, cages and sheet metal parts and components	Springfields Fuels Ltd United Kingdom Nuclear fuel manufacture	Suzhou Nuclear Power Research Institute Co. Ltd China Civil nuclear research and development	

First TWI Training blended learning course goes live

Bookings are now being taken for the first release in TWI's suite of new blended learning courses, covering phased array ultrasonic testing.

Combining a week of eLearning with two weeks of classroom-based tuition, the new course offers a more flexible, accessible and personalised way of achieving this advanced ultrasonic Level 2 qualification. You can study theory and concepts when and where you choose, spend less time in the classroom, and save costs related to travel and accommodation.

To celebrate the launch of its eLearning programme, TWI is including two weeks' free access to the phased array online study material for anyone who enrols before the end of 2015. This additional two weeks' access can be used at any time within 12 months of completing the course, so if you need to refresh your knowledge, you can do so at no extra cost.

Phased array ultrasonic testing (PAUT) is now a widely accepted and frequently mandated method of weld inspection, which can either enhance existing ultrasonic capability or, for certain applications, be used in lieu of radiography.

Phased array is a complex methodology, with no shortcut solution to ensuring its competent use. Upskilling from a conventional ultrasonic operator to a fully certified PAUT technician in accordance with BS EN ISO 9712, and approved certification scheme, requires over 100 hours of training and extensive experience.

TWI's new blended learning package makes achieving this certification more accessible than ever before, allowing you to cover the theory at a time and place that suits you before attending classes for the practical element of the course.

Additional NDT blended learning programmes will be launched in the near future, so keep an eye out for coming opportunities.

To find out more visit the course page on the TWI Training website, email trainexam@twitraining.com or call +44(0)1223 899500.

BS7910:2013 amendment

An amendment has been made to BS 7910:2013, 'Guide to methods for assessing the acceptability of flaws in metallic structures', superseding earlier versions of the procedure.

The December 2013 update of BS 7910, which includes advice on non-destructive testing reliability and more advanced treatment of fracture, has been broadly welcomed by industry.

Extensive user experience over the year following its publication revealed a number of errors, mostly of a minor editorial nature, and ambiguities, leading to this amendment. Published in July 2015, the updated version is known as BS 7910:2013+A1:2015. The amendment, which was further updated to reflect some additional minor corrections in September 2015, will be issued free of charge to purchasers of BS 7910:2013.

The main technical change in the new amendment, arising from user feedback, is a complete change to the K-solution for semi-elliptical surface flaws in bars, as described in section M.10.3 of the procedure. Other amendments, mostly editorial, are clearly indicated by tags.

TWI's consultancy services, training materials and CrackWISE® software will henceforth be based on Amendment 1.

For more information please contact us on +44(0)1223 899000.

Job Knowledge – Arc-based Additive Manufacturing

Introduction

The development of arc-based additive manufacturing (AM) is being driven by the need for increased manufacturing efficiency of engineering structures. Its ability to produce very near net shape preforms without the need for complex tooling, moulds, dies or furnaces offers potential for significant cost and lead time reductions, increased material efficiency and improved component performance.

First patented in 1920, electric arc-based AM is probably the oldest, outwardly simplest, but least talked about of the range of AM processes. Using welding wire as feedstock, the process has been used to manufacture round components and pressure vessels for decades, but not until quite recently has interest in AM in general, and arc-based AM in particular, increased. With a resolution of approximately 1mm and deposition rate between 1 and 10kg/hour (depending on arc source), the operating window of arc-based AM is between, and complementary to, accurate but slower laser-based systems and less accurate high-deposition-rate plasma and electron beam systems.

Figure 1. Robotic AM system at TWI

Arc-based AM equipment

There is not currently a specific commercial arc-based AM system available, but all that is required is a three-axis manipulator and an arc welding power source. The potential range of manipulators is vast, but most fall into one of two types: robotic or machine tool-based. Similarly, there are different types of power source available and to some extent the material in use will drive the arc deposition process selected. For example, titanium alloys are usually deposited with more stable TIG or plasma transferred arc, whilst most other materials are deposited with MIG/MAG equipment. The emerging range of low-heat-input MIG/MAG systems are proving particularly suitable for AM. Figure 1 shows one of the robotic systems used for arc-based AM at TWI; this is an industry standard robotic welding setup which is also used for AM projects. The adaptions for AM on this system include modification of the turntable for endless rotation, modified control software, increased thermal management and robust wear parts in the power source to cope with long arc-on durations.

Machine tool-based systems into which the deposition equipment has been integrated have additional potential to allow the combination of AM and subtractive (cutting) (SM) processes in a layer-by-layer manner, allowing features to be created and finish machined that would not otherwise be possible. There are laser/powder-based combination AM/SM machines available; development of arc-based systems is underway and it is only a matter of time before a system is brought to market.

Arc-based process variables and control

Although described above as 'outwardly simple', arc-based AM is not a simple process to use. Whilst the main controllable variables are the same as robotic welding, AM is a different process. All the process variables combine to produce deposit bead geometry, and it is manipulation of this bead that results in the desired component shape. Unfortunately and unlike welding, bead geometry is affected by more than just the deposition parameters; the residual heat build-up as the part is built results in a continuously changing thermal field that must be accounted for if a deposited layer is to be accurate and free from defects.

As parts become more complex, the programme path of each layer becomes significantly more so. It is rarely possible to strike an arc at the beginning of a layer and extinguish it at the end. Most layers consist of several 'sub-shapes' which are programmed and deposited separately but joined together. Figure 2 shows an example of a relatively simple part, which is made up from ten sub-shapes in four different configurations (ie L, T, angled T and five-legged X).

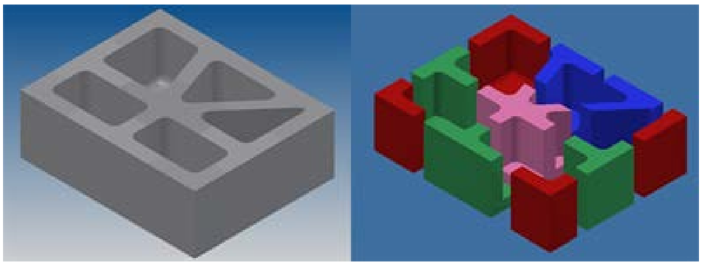


Figure 2. Relatively simple AM part made from ten separate sub-shapes

Until a fully capable AM offline programming software product becomes available, the success of the process is reliant upon the skill of the operator and their ability to break a component down into sub-shapes, decide the order in which they are to be built, predict thermal field, residual stress and distortion, assign appropriate deposition parameters and compile a part programme. Despite the difficulties, examples of some very complex parts have been presented in the public domain.

Materials and deposit properties

As a generalisation, if a material is available as a welding wire, it can be used to manufacture parts by arc-based AM. TWI has deposited materials including carbon and low alloy steels, stainless steel, nickel-based alloys, titanium alloys and aluminium alloys. For many of the materials, the deposit properties are similar to those expected from weld metal in a joint. The notable exceptions to this are precipitation strengthening aluminium alloys and αβ titanium alloy Ti-6Al-4V.

Al-Mg alloys can be strengthened significantly by work hardening after deposition. The strength of heat-treatable alloys will be increased by solution treatment and ageing, but due to the absence of stretching to create nucleation points for precipitates, they are unlikely to be fully equivalent to the peak strength of a T6 tempered wrought material. Aluminium alloy deposits can suffer from porosity, but it can be minimised by the use of special deposition arc waveforms, high-quality consumables and welding best practice for preparation and handling of all materials.

Deposition of Ti-6Al-4V will result in a strongly columnar β grain structure which has isotropic tensile properties. In the horizontal (parallel to the layers) direction, the material will exhibit a 0.2% proof and ultimate strength of 850 and 950MPa respectively, but in the vertical direction these are reduced to 800 and 900MPa. However, it has been shown that introduction of high-pressure rolling as each layer is deposited leads to recrystallisation of the grain structure, resulting in anisotropic tensile properties of 990MPa 0.2% proof and 1070MPa ultimate strength.

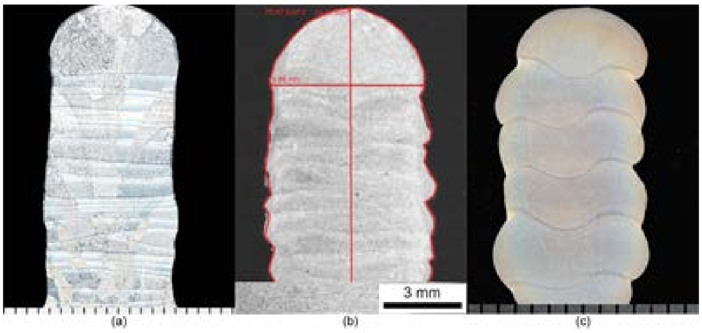


Figure 3 shows macro sections of Ti-6Al-4V, AA 4043 and IN718 arc-based AM walls

Summary

Arc-based AM has significant potential for cost and lead time reduction for medium-to-large engineering components of medium complexity. Careful design for arc-based AM can enable partial topological optimisation and careful selection of wire feedstock can make added material optimisation and multi-material components possible. If AM is combined with a machining platform, it becomes possible to create some otherwise impossible shapes.

Arc-based AM is not a net-shape or automated process at this time; the surface finish (waviness) usually means the part must be finish-machined, but the envelope of material to be removed can be as little as 1mm. Some operator skill is required for successful part build; until commercial AM software becomes available, the part model must be interpreted and the manufacturing process manually prepared.

TWI has developed extensive knowledge of arc-based AM over several years' work in generic and contract research.

If you would like to discuss this topic, or for more information, please contact us on +44 (0)1223 899000.

Case Study: TWI doubles welding speed for supplier of seating decks at London's Olympic Stadium

TWI worked with Member company and aluminium specialist Sapa to support its work to provide seating decks as part of the redevelopment of one of the venues for this year's Rugby World Cup: London's Olympic Stadium.

Sapa Extrusions, based in Harderwijk in the Netherlands, had a contract to deliver 3500 retractable decks for the stadium, which provided an 80,000-seat venue for the 2012 Olympics and Paralympics, but will begin the 2016/17 football season as the 54,000-seat home ground of West Ham United Football Club.

The seating decks were to be made from extruded aluminium, incorporating joints made using friction stir welding (FSW). To meet its production targets, Sapa approached TWI for assistance in increasing the speed at which it was able to FSW the aluminium panels, with an aim to double the 1000mm/min rate it was limited to at the start of the project.

TWI approached the project in two phases. First, suitable process parameters and tool designs were identified through trials carried out at TWI's Great Abington headquarters. Once these had been established, TWI took its findings to Sapa's Harderwijk premises, to apply them in the production environment.

The phase one trials at TWI were carried out on its ESAB SuperStir gantry-type machine. This piece of equipment features a maximum traverse speed of 5000mm/min, a maximum tool rotation speed of 5000rpm, and is capable of exerting up to 100kN of z-axis force on the joint as it works.

A modular jigging system was used to ensure the components being joined were securely held in place, with adjustable side clamps along the weld length. Strong clamping was essential to ensure that the powerful lateral and perpendicular forces generated during welding did not lift the parts being welded or push them apart.

The panels were 6063-T6 aluminium alloy extrusions with 3.5mm skin thickness. TWI was able to select a FSW tool design for the task based on its past experience working with similar alloys.

Having identified a suitable FSW tool and configuration, TWI conducted extensive welding trials to identify the optimised welding conditions for this particular extrusion design. Once a number of test welds had been made, they were visually inspected, subjected to metallographic examination and tested for tensile strength. Results from these tests showed positive results from welds carried out at 3000mm/min.

TWI then travelled to Sapa's Dutch facility to provide two days of on-site support, applying the parameters to the company's own FSW equipment. Tests began using the optimised welding conditions achieved at TWI.

As in phase one, the resulting welds were visually inspected, subject to metallographic examination and tested for tensile strength – with surprising results. Although the welds were visually acceptable, the majority of them were found to contain voids.

The relatively poor result was attributed to a number of possible factors, such as the panels' varying flatness along the weld's 6000mm length; the need for the position of the tool on the z-axis to be adjusted on the fly as the weld took place, leading to inconsistent penetration; insufficient machine downforce; and fit-up issues at the joint line.

TWI subsequently reduced the traverse speed to 2000mm/min to eliminate some of these problems and enable the production of void-free welds.

Following the visit, TWI provided Sapa with suggestions on how to improve their existing clamping system, and Sapa continued to conduct welding trials of its own. Thanks to the support from TWI, Sapa technicians were able to find a 'sweet spot' on their machine, allowing panels to be welded at a speed of 2450mm/min, producing friction stir welded panels with specifications that met their requirements.

During the summer, TWI provided additional support to help Sapa meet its manufacturing target by contributing manpower. Two TWI technicians spent three-and-a-half weeks at Sapa, working double shifts between them.

The combined efforts of TWI and Sapa meant the entire 3500 quota of panels were produced and delivered on time for installation at the Olympic Stadium well before the project deadline, and in time for the 2015 Rugby World Cup. Although England's campaign in the tournament was short-lived, the decking underpinning the retractable seating in the stadium should provide support for sports fans for many years to come.

For more information on TWI's work in weld procedure development, visit the Joining Technologies section of the website.

NSIRC launches open call inviting PhD proposals from leading universities

Industrial research institute the National Structural Integrity Research Centre (NSIRC) has launched an open call to universities around the world for ten PhDs it will fund in 2016.

The degrees, which will focus on structural integrity and systems performance, will be paid for by NSIRC founder sponsor the Lloyd's Register Foundation (LRF), which has committed £15 million of PhD programme funding over ten years.

The LRF recently launched its *Foresight Review of Structural Integrity and Systems Performance* in Singapore, setting out its plan to fund high-quality research that will have a real impact on the safety of life and property. The organisation has already delivered ten PhD studentships through NSIRC this year as it works towards this commitment.

To continue its work to address the structural integrity challenges imposed by complex products and engineering systems, NSIRC is now inviting PhD proposals from universities worldwide. Proposals are invited in the below areas of research from world-leading research universities:

- safety of additive manufactured parts
- advancing the state of the art to maximise safety
- whole-system approaches to demonstrate safety and integrity
- data-centric engineering
- minimising the risks associated with maintenance and inspection.

Please visit the NSIRC website at www.nsirc.co.uk for more information on the 2016 open call and to apply for funding. The closing date for applications is 19 February 2016.

If your organisation or university is interested in partnering with NSIRC, please contact us at enquiries@nsirc.co.uk.

PrinTEG prject update

The PrinTEG project (Production Innovation for ThermoElectric Generators) aims to develop an automated process to provide high-volume production at low costs to satisfy the demands of thermoelectric generator (TEG) applications. PrinTEG is necessary to advance the development of a low-cost automated manufacturing process which has not yet been developed in the UK.

Innovative materials are being developed alongside new processing techniques and the TEG modules that are created will be capable of producing 5 to 20W.

'The development of a low-cost manufacturing method will help to open up the market for TEGs, especially in the automotive sector where CO_2 emissions savings of 24kg/year per vehicle are possible,' says Project Manager Dr Barri Stirrup. 'PrinTEG will allow us to achieve a high TEG production rate and enable energy saving for a broad range of applications. This will help UK and European companies to compete with global manufacturers.'

The PrinTEG consortium consists of European Thermodynamics Ltd, Jaguar Land Rover, Intrinsiq Materials Ltd, TWI and Queen Mary University of London. The project is co-funded by Innovate UK. For more information please contact info@etdyn.com or call +44(0)116 279 6899.

For more information on TWI's joining technologies please contact TWI on +44(0)1223 89000 or visit www.twi-global.com.

Open Day sparks the start of a new era of research for TWI

Over 90 Industrial Members and technical experts visited TWI for the company's first open day in over eight years. It was a day to showcase the breadth of new and existing expertise, capabilities and services at the culmination of a £60m build project to establish technical facilities for a new era of research and education in materials joining and engineering.

3D printing (laser additive manufacture), linear friction welding, and X-ray microscopy were among the eye-catching technical demonstrations presented by TWI staff along the route at the organisation's recent open day at its new buildings in Cambridge.

Chief Executive Christoph Wiesner welcomed visitors with a background to the build project and introduced short presentations on the National Structural Integrity Research Centre for postgraduate education, and a look at highlights from TWI's 70-year knowledge base. Invention and innovation in welding and joining at TWI have shaped the path of progress for many industrial sectors.

Visitors then took part in a tour covering 11 technology stations and more than 10 exhibition areas across five connected buildings and engineering laboratories. Demonstrations and displays represented all areas of TWI business including the world renowned Library, Training and Examinations, The Welding Institute and group company Pi Ltd. During the afternoon, industry guests took part in a series of sector specific briefings and workshops focused on current needs and technical advances.

The open day took place against the exciting backdrop of the live final of the European Welding Federation's WeldCup competition, which saw teams of bright young welders from seven countries competing for the skills award. Winning team Romania, pictured below, beat off the competition from runner-up Germany, with the UK in bronze medal position. Guest team China also scored highly.

Angela Angulo demonstrates a new guided wave inspection tool for oil pipelines

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