NUCLEAR AMRC news
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New look at decommissioning

Innovation for designing, manufacturing and inspecting waste boxes

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Slashing the cost of waste box manufacture

The Nuclear AMRC is working with Sellafield Ltd to slash the cost of making future designs of waste container boxes, potentially saving hundreds of millions of pounds in decommissioning costs.

The clean-up programme at Sellafield and the other sites managed by the Nuclear Decommissioning Authority (NDA) will need tens of thousands of special steel boxes over the next 30 years to safely store and dispose of hazardous waste. The current design is a standardised 3m³ stainless steel box which can be stacked for long-term storage.

Making these boxes using current manufacturing techniques is an expensive business, with each one costing tens of thousands of pounds to produce. Sellafield Ltd is driving a project to significantly reduce that cost, and tasked engineers at the Nuclear AMRC to help come up with solutions which could save the taxpayer hundreds of millions of pounds over the lifetime of the programme.

"This is a challenging project requiring a fully multi-disciplinary approach, bringing together many areas of research, with the potential to deliver significant savings to industry," says Stuart Dawson, Nuclear AMRC chief technology officer. "With our world-leading capabilities and expertise, the Nuclear AMRC is uniquely positioned to address such complex manufacturing problems for demanding sectors like decommissioning."

The research focuses on the two most promising routes for cost reduction identified by Sellafield Ltd – optimising and automating welding of the container; and producing the lid flanges by casting instead of machining.

In the first phase of research, Nuclear AMRC research engineers worked alongside a specialist welding engineer from Sellafield Ltd, Jade Leonard, to investigate new approaches including fully automated welding and inspection. The complex design of the boxes means that many joints are not easily accessible to current mechanical welding tools, so the team investigated small flexible welding heads that can fit into tight spaces and weld in several directions using a range of welding technologies.

The team are focusing on the highly corrosion-resistant duplex 2205 stainless steel, which can present significant challenges during manufacturing.

"We have to control the heat that's applied during welding, because that can affect the metallurgy of the steel," says Leonard.

"Duplex has a 50:50 mix of ferritic and austenitic steel, and we need to be careful that we maintain that balance because that affects corrosion resistance."

The team have completed initial trials with a range of arc and laser welding technologies, using equipment at the

Robot eyes: the Nuclear AMRC is developing automated inspection techniques for waste containers.

Casting the near-net: a prototype lid flange emerges from the casting box.

Nuclear AMRC and at specialist welding partners, and identified the most promising for further development. In the ongoing second phase, the welding team are using the chosen technologies to produce more complex representative testpieces.

Duplex steel's high strength also makes components difficult to machine. High residual stresses in the material can lead to changes in geometry when it's machined or welded.

"This stress relief is extremely difficult to prevent or to even predict accurately, meaning that the precise geometry of the box components is very difficult to control as they progress through the manufacturing process," says Dave Stoddart, Nuclear AMRC technology lead for integrated manufacturing.

The Nuclear AMRC has installed a new robotic cell to develop automated inspection techniques which can ensure that boxes produced with new techniques meet specification. The six-axis robot arm carries a photogrammetry head, which rapidly builds up a detailed three-dimensional image of the box's geometry. The automated cell then analyses this model and identifies any distortions or defects within minutes, rather than the days needed for inspection on a traditional coordinate measuring machine (CMM).

To investigate new casting techniques for the top flange, the Nuclear AMRC called on the specialist expertise of AMRC Castings – part of its sister centre, the University of Sheffield's AMRC with Boeing.

The top flange, a large and complex hollow square with four corner lifting features, is currently produced by machining from a solid block, with most of the expensive high-grade alloy being cut away.

AMRC Castings investigated whether the complex shape could instead be cast as a single item. Using the centre's Replicast ceramic mould technology, the team successfully cast two highly accurate, one-piece prototype frames. The frames have passed material and metallurgical testing, and exhibited a superior surface finish.

"Using a near-net shape casting optimises metal use, saves a massive amount of work, and significantly reduces the task of inspecting the finished product to make sure it meets stringent nuclear standards," says Richard Gould, commercial manager at AMRC Castings.

The Nuclear AMRC's machining group will now investigate how the cast part can be finished to the final precise specifications, while maintaining geometrical accuracy and surface integrity.

The research is part-funded by the Civil Nuclear Sharing in Growth (CNSIG) programme, which aims to develop the UK manufacturing supply chain for civil nuclear with support from the Regional Growth Fund. The results will be shared with UK manufacturers which can produce the boxes to the required specifications.

www.sellafieldsites.com

De-risking by design

Nuclear AMRC welding specialists have helped Nuvia identify ways to improve the manufacturability of a new waste transport package.

The Novapak container is designed to carry up to four 200 litre drums of higher active waste to Sellafield for treatment. They will replace the current fleet of packages used by LLW Repository Ltd, the site licence company for the UK's low level waste repository in West Cumbria.

Nuvia, a leading decommissioning specialist and tier two member of the Nuclear AMRC, is working with LLW Repository as the package design authority for Novapak. Nuvia approached the centre's engineers to look at potential improvements in manufacturability based on modern manufacturing techniques.

The Novapak is made primarily from 304L stainless steel, a low-carbon austenitic steel designed for use in aggressive corrosive environments. However, 304L is more prone to distortion and residual stress than other steels, and can increase risk during the manufacturing process.

Nuclear AMRC welding engineer Xiaoying Honey identified a number of areas that posed particular risks, including distortion during fabrication and fatigue during service. The team also proposed ways to reduce these risks including modified weld procedures, improved jigs and fixturing, and 3D weld modelling.

The recommendations resulted in a number of changes to the Novapak design.

"The Nuclear AMRC provided an excellent service for this collaborative piece of technical engineering de-risking work," said Alan Jackson, programme manager at LLW Repository. "It was an important step for the manufacturing project to go through, before we committed to making a significant financial investment."

www.nuvia.co.uk

llwrsite.com

Secondee thoughts on collaboration

Sellafield engineer Kristian Stephens has been seconded to the Nuclear AMRC to support collaborative R&D for the decommissioning sector. We asked him to introduce himself.

Supporting collaboration: Kristian Stephens with the Nuclear AMRC's inspection robot.

I joined the Nuclear AMRC in June on a six month secondment from Sellafield Ltd to support our joint R&D programme on the manufacture of waste containers to store radioactive waste from nuclear decommissioning.

Over the lifetime of the Sellafield mission, many thousands of waste containers are expected to be required to facilitate the safe disposal of the large quantities of radioactive waste stored in legacy facilities on the Sellafield site. This presents a significant opportunity for applying and developing advanced manufacturing technologies through collaboration with the Nuclear AMRC and its partners.

My background is in materials science. I graduated with a Masters degree from the University of Cambridge in June 2015, before joining the Sellafield Ltd graduate scheme in September. In my base department role, I provide materials science and engineering support to the Inspection and Certification Group, which is the nominated inspection authority for Sellafield Ltd. This involves ensuring that plant fabrications and equipment meet the required standards of quality for use in the demanding conditions and environments encountered in many decommissioning applications.

I have also worked closely with members of Sellafield's Materials Science and NDE Centre of Expertise, supporting technical assurance activities and managing a small number of research and development projects.

The waste container research programme at the Nuclear AMRC is currently focused on developing improvements to the manufacturing processes used to produce 3m^3 boxes to store intermediate level waste. These improvements will enable more cost-effective manufacture of these containers to the required quality and performance capability. My involvement incorporates technical support on welding, casting, machining and metrology aspects of the project, as well as providing customer oversight.

While at the Nuclear AMRC, I will also be lending my time to support project teams working in related sectors and to contribute to the Nuclear AMRC's business development activities. This will include working with Sellafield Ltd and its supply chain to develop their ideas into collaborative R&D projects that deliver real value to future decommissioning projects.

I am excited to be working alongside a team that is at the forefront of innovation in the nuclear industry. Since joining the Nuclear AMRC, I have been amazed by the range of capabilities that the centre has at its disposal. From bulk additive manufacturing and electron beam welding to advanced machining and large-volume metrology, the scale and precision of the Nuclear AMRC's world-leading resources are truly impressive.

Please get in touch to find out more and discover how the Nuclear AMRC can help enhance the capabilities of Sellafield's supply chain partners.

Kristian Stephens

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New framework for decommissioning R&D

The Nuclear AMRC is part of a new consortium providing innovative technical solutions to the Nuclear Decommissioning Authority (NDA).

The Unity 2 consortium is one of a series of groups given R&D framework contracts worth up to £12 million over four years. The new approach, dubbed the Direct Research Portfolio (DRP), focuses the NDA's funding on research which can deliver innovation across multiple sites and develop new technical expertise in a range of common areas.

Unity 2 focuses on integrated waste management and site decommissioning, and combines innovation with hands-on experience of decommissioning and site restoration. The consortium is led by Lancashire-based NSG Environmental, and includes a mix of large international companies, smaller specialist businesses, research organisations and universities.

The DRP approach is intended to speed up innovation by offering contracts to bids from ready-made research collaborations, and to provide a greater role for small and medium-sized businesses.

The DRP contracts will also address cross-industry R&D requirements identified by the industry-led Nuclear Waste and Decommissioning Research Forum. DRP projects often lead to more extensive R&D projects carried out by the NDA's site licence companies and their supply chains.

The Tynan view

Nuclear manufacturing **after Brexit**

Writing one month after the UK's vote to leave the European Union, this is my view of what Brexit might mean for our industry and for our mission in advanced manufacturing research and development.

As a country, we will continue to safely operate 15 nuclear reactors for their planned lifetimes; we still need to retrieve, condition and store significant volumes of nuclear waste; and we still plan to build new nuclear power stations to replace our existing nuclear fleet. Leaving the EU will not change those necessities, and our mission at the Nuclear AMRC remains unchanged: we are here to help UK manufacturers win work in the civil nuclear industry.

In nuclear new build, all three developers have said that their plans remain unchanged. As I write, EDF is preparing to make its final investment decision – a much-needed fillip for a UK new build programme that has seen successive delays. However, we also have to consider that the decision to leave the EU creates ongoing uncertainty in the marketplace, at least in the short term, and that could well affect access to capital and impact investor confidence.

I suspect that the main impact on Brexit for the Nuclear AMRC will be on the funding of our work programmes. While we face the industry challenges side by side with our industrial partners, our funding relies on income from government and commercial R&D work. European research funding might no longer be available to us on the basis we have known, but I am confident that the UK will wish to remain competitive in manufacturing. I believe that the UK government will not abandon the excellent work delivered through the High Value Manufacturing Catapult, of which we are part. Indeed, senior government officials have already made statements about an increased emphasis on ensuring UK competitiveness in advanced manufacturing.

In recent years, we have placed increased emphasis on the need for substantial commercial income to ensure the sustainability of our centre. This drive is now of prime importance for us. Without commercial income, we rely on funding streams that are largely part of political agendas, and we have witnessed first-hand how politics can be subject to upheaval in a very short space of time. Our sustainability relies on industrial partners for whom we provide solutions to business challenges.

One immediate impact of Brexit is a likely reduction in income for our owner, the University of Sheffield. This could impact jobs at our centre and we will have to make sure that we are the right size for the work programmes we have to deliver. Where we provide value to the nuclear industry and its supply chain, and industry is prepared to pay for that value, then we secure our own future.

Another immediate impact has been the negative effect on the value of sterling. On the positive side, a weak pound means UK exporters can be more competitive on cost. On the negative side, many costs including energy and other industrial inputs will rise. We will continue to seek out and sustain the positive impact on our business. This will not be easy, and we have to make sure that we have the right skills and competence to understand our markets and deliver for our customers.

With a new government facing up to the challenges of political and economic life post-referendum, we too will face up to the same challenges. Business never stands still, and one of the many things I have learned in my career is that we have to be agile and move with change. Where possible, we have to be ahead of change – this is the zone where winners operate, and this is where I expect we will operate to deliver sustainable value into the civil nuclear industry.

Mike Tynan, CEO, Nuclear AMRC

EDF approves Hinkley Point investment

EDF has confirmed it is ready to invest in two new nuclear reactors at Hinkley Point in Somerset.

EDF made its final investment decision (FID) at a meeting of directors on 28 July, as this newsletter went to press. Following the vote, the UK government announced that it is reviewing its support for the project and will make a decision in early autumn.

For full details and commentary: namrc.co.uk/industry/hinkley-point-fid

Polysoude showcases new arc technology

State of the art: orbital welding observed by Polysoude engineer David Martins.

Welding specialist Polysoude, a tier two member of the Nuclear AMRC, brought 85 UK manufacturers to the centre to see the state of the art in mechanised arc welding and cladding.

The two days of masterclasses featured live demonstrations of mechanised welding and cladding technologies, as well as orbital processes for tube-to-tube and tube-to-tubesheet welding, using the production-scale facilities in the Nuclear AMRC workshop.

The star of the show was the new TIGer system provided by Polysoude. The Nuclear AMRC's new facility is one of the few currently installed in the UK.

TIGer is a bi-cathode hot wire cladding system that can clad at up to ten times the speed of conventional systems based on tungsten inert gas (TIG – also known as gas tungsten arc welding or GTAW), while maintaining material quality.

Polysoude says the technology represents the next evolutionary stage in hot wire TIG technology, allowing 20–50 per cent savings in operating cost per kilogram of weld metal.

The TIGer equipment is part of a major upgrade of the Nuclear AMRC's Polysoude arc welding cell, which now features two large columns and booms. Capabilities include narrow groove welding with synchronised oscillation, butt welding, conventional cladding, plasma keyhole welding, orbital pipe welding and planetary bore cladding.

The Polysoude masterclasses, held on 8-9 June, also featured talks on advanced welding techniques from Polysoude chief executive Hans-Peter Mariner, Nuclear AMRC head of welding Keith Bridger and Professor Steve Jones of Coventry University's Institute for Advanced Manufacturing and Engineering.

Delegates also heard from manufacturers including Alan Robinson of Arc Energy Resources, Norman Cooper of BAE Systems and Charles Byrne of Graham Hart Process Technology about their own experiences with advanced welding technologies.

Polysoude is a global designer and manufacturer of orbital welding equipment and automated solutions for modern arc welding processes and techniques. Headquartered in Nantes, France, it joined the Nuclear AMRC as a tier two member in 2012.

Nuclear AMRC members can use the centre's facilities for their own technology events. Upcoming events include a showcase for the centre's ultra-high precision Leitz PMM-C coordinate measuring machine, arranged by Hexagon Manufacturing Intelligence.

www.polysoude.com

Joined-up research for Catapult centres

Welding researchers at the Nuclear AMRC are working with colleagues at two other centres in the High Value Manufacturing Catapult to develop new techniques for joining dissimilar metals.

CATAPULT
High Value Manufacturing

The project is investigating solid state welding processes which could be used to produce metal connectors and couplings for industries including nuclear, chemical, and oil and gas.

Researchers at the Advanced Forming Research Centre (AFRC) at the University of Strathclyde are working on new forge welding techniques for joining different metals. These techniques require specially welded preforms to keep the components together as they're heated and handled before being forcibly joined.

The Nuclear AMRC is using its Pro-Beam K25 electron beam chamber and arc welding facilities to produce a series of preforms of dissimilar metal rings for trials at the AFRC. Researchers at the centres will then work together to compare the performance of the preform welding techniques and their effects on the final forge weld.

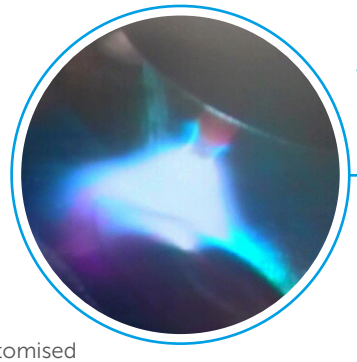
Researchers at the Manufacturing Technology Centre (MTC) in Coventry are meanwhile using rotary friction welding techniques to join the same kind of dissimilar components.

The final welds will undergo mechanical testing and microstructure characterisation to identify the most promising techniques for further development.

The project is part of a series funded by the HVM Catapult to allow the individual centres to work together on new capabilities and innovative manufacturing technologies. The HVM Catapult includes seven specialised manufacturing research centres, and is supported by the national innovation agency Innovate UK.

New additive technique could lower costs

Nuclear AMRC additive manufacturing researchers have successfully demonstrated a new lower-cost technique for making or repairing large components from metal powder.



Arc light: the new technique combines blown powder with standard welding technology.

The technique is a blown powder process, in which metal is delivered as a finely controlled stream into a welding torch. Blown powder processes are already used for additive manufacturing and cladding, using specialised laser or plasma welding tools to fuse the powder into shape.

The process developed by the Nuclear AMRC team however uses a standard gas tungsten arc welding (GTAW) head.

"There's a lot of emphasis on laser and plasma welding, where the input energy is usually far in excess of what's required to fuse the metal," says Udi Woy, additive manufacturing technology lead at the Nuclear AMRC. "We're looking at a lower energy input using arc welding. It's a lower-cost approach using standard welding technology, which should improve the commercial appeal."

The prototype tool uses off-the-shelf consumables, which the team customised with an integrated powder feeder. The process was demonstrated in the Nuclear AMRC's shaped metal deposition (SMD) cell to produce a series of test pieces from 316L stainless steel powder.

The SMD cell was originally developed for additive manufacturing using GTAW and wire, and is now used as a proving chamber for the Nuclear AMRC's bulk additive manufacturing (BAM) facility. The 50m^2 BAM cell is designed to investigate a range of techniques for building and customising large high-integrity parts, with a six-axis robot carrying a variety of modular end effectors.

"We're developing this innovative process in the small cell to prove the concept, and can then introduce the end effector to the larger BAM cell," says Woy. "It's part of our ongoing work to develop end effector tooling and de-risk the technology."

The team will now analyse the samples produced by GTAW powder and wire processes to assess their effects on microstructure and mechanical properties.

Ultimately, powder and wire-fed tools could be combined in a single modular system for additive manufacture and repair. "If you're building a large part using wire-based additive, you can potentially use a fine spray of powder to improve the surface finish," Woy notes.

This work is funded by the High Value Manufacturing Catapult, as part of an ongoing programme to develop bulk additive manufacturing capabilities for the nuclear industry and other quality-critical sectors.

Professorship for welding head

Keith Bridger, head of welding and materials engineering at the Nuclear AMRC, has been appointed professor of welding engineering practice at the University of Sheffield.

Bridger leads the Nuclear AMRC's team of around 35 engineers and technologists delivering welding, additive manufacturing and materials R&D solutions for industrial partners. He is a Chartered Engineer and Fellow of The Welding Institute and the Institute of Materials Minerals and Mining.

"I am delighted as well as very proud to be appointed a professor," Bridger says. "It celebrates success on a very personal level, but also reflects on the great team of colleagues that I've managed to build during four and a half years at the centre.

"It's also very good for the profession of welding engineering. There are very few professional welding engineers in the UK, and the fact that one of the fraternity has risen to the title should be inspiring for younger engineers."

Before joining the Nuclear AMRC in 2012, Bridger spent over 35 years with Rolls-Royce where he was appointed company welding engineer with responsibility for all welding-related activities within the submarines business.

"When ex-colleagues asked me how my transition from a corporate giant to an innovation centre like the Nuclear AMRC had gone, I used to say that it was like having a shot of adrenalin in the arm," he says. "All I can say is that this honour is like having another shot, and will hopefully keep me in the profession for a few more years."

namrc.co.uk/capabilities/innovation/welding

NuScale seeks UK partners for SMR manufacturing

Delegates from over 100 manufacturing companies came to the Nuclear AMRC to discuss working with NuScale Power on UK production of its small modular reactor (SMR).

The US-based reactor developer held its first UK supply chain event as it strengthened its links with the Nuclear AMRC and announced a new collaboration with Sheffield Forgemasters (see right).

The event on 13 July featured presentations from NuScale's senior management and key partners, as well as one-to-one sessions between manufacturers and NuScale's supply chain managers.

NuScale's Power Module is a 50MWe pressurised water reactor and generator, designed to be deployed in clusters of up to 12 per site. The combined containment vessel and reactor system is small enough to be transported from a factory to site by road, rail or barge.

Power Module: cutaway of NuScale's reactor design.

NuScale has submitted an expression of interest to the UK government's ongoing competition to identify the best-value SMR for the country. If successful, the company plans to establish a new UK manufacturing facility operated by local partners.

"Our objective is to become the UK's selected supplier for SMR technology to support this country's needs for clean low-carbon energy," Mike McGough, chief commercial officer for NuScale, told delegates. "This requires a very strong team of local partners. We're committed to localisation – we're looking not just for suppliers, but for strategic partners."

Last year, NuScale announced a strategic partnership with Ultra Electronics, the UK-based specialist in high-integrity sensors, protection systems and nucleonic equipment.

"It's an opportunity to rebuild some of our nuclear engineering capability and create genuinely UK IP and knowhow," Nick Gaines, managing director of Ultra Electronics' nuclear control systems business, told delegates. "Small units are good business because you can talk about having a production line. And working with a new nuclear vendor, you're looking at 60–100 year lifetime for a plant – it's not just about building a product now, it's about a lifetime of supporting a plant."

Although a NuScale plant is much smaller than the current design of gigawatt-scale reactors, with a design that minimises the need for active safety systems, each will present major opportunities for suppliers of precision engineered components – including over 39,000 valves, over 900 other mechanical components, over 12,000 instruments and 46,000 metres of pipe. Each Power Module will have its own dedicated steam plant, so each site will have up to 12 individual balance-of-plant systems.

Not actual size: NuScale's Mike McGough demonstrates a model Power Module.

"The quantities are high, but the systems are small," said Scott Bailey, NuScale's vice president for supply chain. The supply chain model is more like that of an aerospace prime such as Boeing than it is like traditional plant construction, he noted: "It's about creating a supply chain, and building relationships with people so that products are standardised."

Technology being developed at the Nuclear AMRC – including large-scale advanced machining, electron beam welding and diode laser cladding – can significantly reduce cost and improve quality for SMR manufacturing, Mike Tynan told event delegates.

"There is game-changing technology, but we will need targeted investment for SMRs," he said. "The market analysis indicates that there's definitely a substantial global opportunity for SMRs, but if we want to participate in that, we will have to succeed and deliver locally."

NuScale has strengthened its relationship with the Nuclear AMRC by becoming an official supporter of the centre's work with UK manufacturers on developing innovative manufacturing techniques. The two organisations signed an initial memorandum of understanding in late 2014.

www.nuscalepower.com

New alliance for Forgemasters

Sheffield Forgemasters and NuScale Power have announced a new partnership to develop manufacturing techniques for the future deployment of small modular reactors (SMRs) in the UK.

Forgemasters, a founding member of the Nuclear AMRC, will produce a demonstration forging of NuScale's reactor vessel head by the end of 2017. The work is part of an ongoing research project supported by Innovate UK to develop and validate innovative forging and fabrication solutions for the nuclear industry.

The £4 million project, funded under Innovate UK's Energy Catalyst programme, has been running since June 2015. It is led by Sheffield Forgemasters, with partners including Rolls-Royce, The Welding Institute, the University of Sheffield, Sheffield Hallam University and the Nuclear AMRC.

NuScale Power will now be an observer in the project, and is providing additional funding to support the use of its reactor vessel head geometry for the demonstration forging.

Forgemasters has a long history of manufacturing large steel components for heavy engineering and nuclear power applications. It is the UK's only large forgemaster, and a world leader in large-scale forged and cast components.

"Small modular reactors could revolutionise the civil nuclear power industry by creating more flexible power generation solutions," said Forgemasters chief executive Graham Honeyman. "The efficient factory manufacture of major components will be crucial to seeing them deployed cost-effectively, and Sheffield Forgemasters has an unparalleled track record in the production of civil nuclear forgings of this size.

Heavy forging: demonstration pressure vessel head takes shape at Sheffield Forgemasters.

"NuScale's design is one of the most advanced in the world and this forging project will allow us to prove yet again that UK manufacturing is at the leading edge of global technological advancement."

www.sheffieldforgemasters.com

Technology roadmap identifies SMR priorities

The Nuclear AMRC brought together eight reactor developers with manufacturers along the supply chain to discuss the technology challenges facing small modular reactors (SMRs).

The technology roadmapping event, held in May, aimed to identify and prioritise the advanced technologies required for SMR development in the UK, as well as the challenges facing local supply chains.

"We held this roadmapping event to bring together all the parties with a direct interest in UK SMR development, and to begin mapping the generic manufacturing R&D challenges which we collectively need to address," says Johnny Stephenson, the Nuclear AMRC's business development manager for SMRs. "SMR development in the UK will create significant opportunities for manufacturers, so it's vital that potential suppliers understand the challenges and take action at an early stage."

The event was attended by representatives of 34 organisations including reactor technology developers, utility companies, research institutions and manufacturers along the supply chain, who collectively raised around 300 topics for discussion.

The need for innovative technologies to reduce lead time emerged as a common theme, with a variety of processes, technologies and services identified as potentially benefiting SMR manufacturing. These included many techniques already being developed at the Nuclear AMRC, including near-net shape manufacturing, robotic machining, automated high-deposition welding, automated inspection and NDT, and virtual engineering.

"The key driver for SMR manufacturing is risk reduction through minimising lead times and ensuring quality," Stephenson notes. "Advanced manufacturing processes can reduce risk at all stages of plant development, but there's an urgent need to make sure that research funding and support is available to bring these technologies to commercial readiness."

Other issues discussed included conformance of new designs to multiple standards used worldwide, and the opportunity for new codes and regulatory assessment methods to allow greater use of innovative manufacturing techniques.

Full roadmapping results are now being shared with participating companies and Nuclear AMRC members.

The event formed part of a series of roadmapping exercises organised by the Nuclear AMRC to address emerging opportunities and challenges for the UK supply chain. Most have focused on core areas of manufacturing technology, including machining, arc welding, large-scale metrology and bulk additive manufacturing. The centre also leads technology roadmapping in wider areas on behalf of the High Value Manufacturing Catapult, with the results influencing national research funding priorities.

To find out more about opportunities in SMR manufacturing, contact: johnny.stephenson@namrc.co.uk

Human performance **vital for safety culture**

The Nuclear AMRC has introduced human performance standards across its operations, to make sure it meets industry expectations for nuclear safety culture.

Only human: all Nuclear AMRC staff have been trained in error prevention tools.

Human performance is about reducing the risk of human error in all aspects of a business's operations. It includes a series of error prevention tools which, when used effectively, improve safety and quality performance.

"At the Nuclear AMRC, we recognise that enabling our workforce to carry out their tasks in an environment that promotes good behaviours will help us drive towards our goal of error-free performance," says Paul Bunting, environmental, health, safety and quality (EHSQ) manager. "By integrating error prevention tools such as pre-job briefings, questioning attitude, procedure adherence, peer checking and self-checking into our normal working practices, we will be able to achieve the highest quality performance in the safest possible manner."

The programme was led by the Nuclear AMRC's EHSQ team, working over the past year with specialist trainer Mike Shannon of HPL Ltd. Human performance tools are an important part of nuclear safety culture, which is vital for companies and institutions working in the industry, Shannon notes.

"The nuclear new build companies require supply chain organisations to be able to demonstrate they have a nuclear safety culture, and their staff understand what they are producing, constructing or building," he says. "It is important for staff to recognise that a nuclear facility is special and unique. This – along with the human error prevention tools, open reporting and lessons learned combined with good leadership – makes for an excellent nuclear safety culture."

All Nuclear AMRC staff have now completed training in error prevention tools. Twelve staff members have been accredited as human performance leaders, qualified to observe colleagues as they work and to provide coaching.

"The Nuclear AMRC is an interesting facility in which to introduce a human performance programme, but in many respects is no different to any other organisation," Shannon concludes. "It is early days on the human performance journey, but as long as the leaders are reinforcing clear standards and expectations, the Nuclear AMRC will continue to make good progress."

Dame Sue highlights **the gender agenda**

One of the UK's leading nuclear experts visited the Nuclear AMRC to lead a forum on gender balance in engineering.

Life lessons: Dame Sue Ion discusses her distinguished career.

Dame Sue Ion – former group director of technology at British Nuclear Fuels Ltd, former member of the UK Council for Science and Technology, and chair of the UK's Nuclear Innovation Research Advisory Board – talked about her career to guests from across the University of Sheffield. Her talk focused on her experiences of gender balance in the engineering sector, and why the engineering industries need a broad and diverse workforce to thrive.

Dame Sue admitted that she has been lucky with a career covering 27 years at BNFL – where, she recalled, her main problem was finding a labcoat that fitted – and an international role that took her from reactors in Siberia to observatories in Hawaii.

But there is still a serious shortage of women in the engineering sector, particularly in the UK, she noted. That restricts the pool of talent entering the industry, and loses the creative benefits that come from a diverse team.

Part of the problem is that girls are losing interest in science – particularly engineering-related subjects – at an early age.

"Helping schoolkids to enjoy science and engineering is the most important thing you can do," Dame Sue emphasised. "We have got to be able to compete on the global stage in engineering, because that's what the future's all about."

The event was organised by Nuclear AMRC research engineer Kathryn Jackson, to mark the submission of the centre's application for the Athena Swan Bronze award. The Athena Swan scheme recognises commitment to advancing the careers of women in science, technology, engineering and related fields at universities and research institutions.

Preparing the submission was a challenge for the Nuclear AMRC, chief executive Mike Tynan noted in his opening presentation.

"To simply help people understand that there's a real issue with gender balance in typically male-dominated industries is a challenge in itself, let alone to actively commence an action programme to change the way we approach people, their employment and their development," Tynan said. "Through Athena Swan values and the action plan we put together and are pursuing, we will deliver excellence in people at the Nuclear AMRC."

F4N advisors ready to work with **the best of British manufacturing**

Five manufacturing experts have joined the Fit For Nuclear team to help even more UK companies get ready to win work.

Fit For Nuclear (F4N) is a unique service to help UK manufacturing companies prepare to bid for work in the civil nuclear supply chain, delivered exclusively by the Nuclear AMRC.

Paul Cook, John Olver, John Coleman, Stephen Linley and Huw Jenkins have now joined the Nuclear AMRC as dedicated F4N advisors. All have previously been involved with the F4N programme – Cook since the programme's inception in 2011, and the others through the government-backed Manufacturing Advisory Service (MAS) which has now been wound down.

"We've all worked with manufacturing companies, and a lot of us have run our own businesses. We've been there and done it, and can empathise with companies," says Linley. "We've all learned a lot about the nuclear industry through F4N, and can now use our skills to help more manufacturers succeed in nuclear."

After intense training with the Nuclear AMRC's lead supply chain consultant Martin Ride, the five are now hitting the road to identify and support manufacturers who could join the nuclear supply chain.

"We'll be on site with clients, taking them through their journeys, and introducing them to what the nuclear industry expects from their potential suppliers," says Coleman. "There's a lot of really excellent companies out there still. Part of our role is uncovering those companies, and then helping them develop themselves for the nuclear industry."

"F4N is not for everybody, but it is identifying where there's excellence and capability that can be developed to make a real contribution to the supply chain," notes Jenkins. "It's about working with companies that really want to develop themselves."

Many of the almost 100 companies which have already completed their F4N journey have reported benefits across their business, not just in their nuclear operations. The advisors agree that the lessons of F4N will prove particularly valuable to companies dealing with increased economic uncertainty following the vote to leave the EU.

"It's all about working with the top end of the very best of British manufacturing," says Olver. "It's not quick and easy, it's very rigorous, but the rewards for the long-term future are there to be had. If you do have to deal with difficult conditions, it can give you enough of an edge to help you win work."

Fit five: Paul Cook, John Olver, John Coleman, Stephen Linley and Huw Jenkins (L-R).

"What we want to do is support businesses to help them be more competitive in the market, which can only help," Cook concludes. "Go online and take the plunge. If you want to be more competitive, take the F4N route."

namrc.co.uk/services/f4n

James Fisher Nuclear wins work in UK and Japan

Specialist engineer James Fisher Nuclear has won two major contracts to support decommissioning at Winfrith, Dorset, and clean-up at Fukushima, Japan.

James Fisher Nuclear (JFN) specialises in designing and providing technology for work in challenging environments.

The Lancashire-based firm is one of 10 companies receiving high-intensity business development through the Civil Nuclear Sharing in Growth programme, managed by the Nuclear AMRC with support from the Regional Growth Fund.

Under a four-year, £60 million contract with Magnox, JFN will deliver a facility for the remote segmentation and packaging of the largest reactor core at the Winfrith site. The experimental 100MW heavy water reactor was built in the 1960s and shut down in 1990.

JFN has also secured a high-value contract with Mitsubishi Heavy Industries (MHI) to develop new technology to sample radioactive debris beneath the reactor cores of the damaged Fukushima Daiichi power plant.

"This award shows that our expertise and experience is recognised and valued worldwide," said Bertie Williams, business director at JFN. "Few businesses in the nuclear arena realistically have the experience and personnel with the capabilities to take on such a challenging task, and we are looking forward to working with MHI to design and develop this technology."

www.jfnl.co.uk

Forging into new markets

Specialist forgemaster Abbey Forged Products is targeting opportunities in new markets after completing the Fit For Nuclear programme.

F4N
Fit For Nuclear

Hammer time: Abbey specialises in open die forging.

Founded in 1982 to supply stainless steel bar and forgings on short lead times, the family-owned business acquired forging, machining and heat treatment facilities in 2004. From its integrated manufacturing facilities deep in the woods on the outskirts of Sheffield, Abbey rapidly established itself as a leading supplier to the oil and gas industries, providing forgings up to 1800kg on often demanding schedules.

"Our USP is our short lead times," says business development manager Lee Thomas. "We keep extensive stock so we're not waiting on a third party – all operations are carried out on site, from forging billet right the way through to a finished product. We do lead times as fast as seven days for forged products. We don't think there's anyone else offering that kind of service in the UK."

But with low oil prices forcing a major slowdown in the oil and gas sector, Abbey's management team looked to diversify into other high-value markets. "We have supplied to the nuclear sector in our history, but the oil and gas took over," notes managing director Jackie Neal. "We were sufficiently busy with that not to pursue other sectors."

The team were aware of the Fit For Nuclear programme and started talking to the Nuclear AMRC in late 2015, taking the assessment in February this year. They were able to draw on their previous experience of driving business improvements to rapidly progress their F4N journey, with an action plan created and introduced in around two months.

"It was a fairly quick process, which fitted in line with where we were at," says quality manager Alan Oldale. "We've used it as a platform to raise the culture and best practice on the site. A lot of our efforts

Bright future: Lee Thomas, Jackie Neal, Steve Savage and Alan Oldale.

over the past couple of years were focused on manufacturing excellence, but F4N combines the business excellence side as well. It helped us understand that we are doing the right thing, and benchmarked us against the direction we were going."

Thanks to the team's established focus on manufacturing excellence, the F4N assessment didn't identify any major gaps in Abbey's operations. "It's allowed fine tuning of what was already in process," Thomas says.

The F4N advisors did identify opportunities for new quality tools and additional training, which have been embraced by the firm's 200-plus workforce. "Engagement has been very good at all levels," notes Oldale. "From the strategic approach right down to projects, the buy-in has been immense. The action plans and opportunities for improvement all made it easy to deliver, so it was a good process for us."

F4N has also helped the team focus on its capabilities for supplying critical components to other high-value sectors. "We've had a domino effect – we've just about completed our SC21 approval, and are probably two-thirds of the way down the AS9100 route for aerospace," says Steve Savage, strategic operations manager. "It gives us the agility to be able to respond to whatever requests come in."

While new nuclear orders are unlikely to be a major source of work in the short term, Abbey is already seeing enquiries for the longer term.

"We have started selling the fact that we're Fit For Nuclear, and there has been interest from customers who are in the nuclear sector," Thomas says. "It's good that we're involved now and we can start formulating relationships through the Nuclear AMRC, meeting buyers and introducing our capabilities. When that work does start to filter down to the market, we will be well positioned rather than trying to jump in at the last minute."

"Nobody expects it to happen overnight, but we just have to work away at it," Neal concludes. "We've got a culture here that we want to move forwards all the time and improve, and F4N is part of that journey."

www.abbeyforgedproducts.co.uk

Lestercast takes first steps into nuclear

Fit For Nuclear

Investment casting specialist Lestercast is exploring opportunities in the nuclear sector after completing the Fit For Nuclear programme.

Hot metal: Lestercast specialises in small high-precision castings.

Founded in 1972, Lestercast has grown significantly since Chris Batty and Malcolm Healey acquired the business in 2001. The firm operates in over a dozen sectors from architecture to motorsports, casting precision products ranging from pump impellers for oil and gas to the 'B' on the bonnet of the Bentley Mulsanne.

Lestercast has also led investment in new capabilities and processes, including a range of rapid prototyping technologies. The firm produces parts up to 20kg from its investment casting centre in north Leicester, as well as high-volume parts of up to 150kg through a partnership with a foundry in China. Lestercast now employs 44 people with a turnover of around £8 million, with some 60 per cent of production exported.

The firm had no experience in the nuclear sector when, in early 2015, managing director Batty learned of F4N from contacts at business advisor Pera Consulting. "We saw nuclear as a future market that was worth developing," he recalls. "Since taking the assessment, we've put of a lot of time and effort into bringing together the different aspects that nuclear requires, which are different from what we were used to. Getting ourselves up to speed has been a bit of an experience, but it's been worth the effort to do it."

Lestercast had already achieved quality certifications including ISO 9001 and the automotive ISO TS16949 standard, so the F4N assessment didn't provide any major challenges to the team. The first assessment scored the firm highly in operational areas such as quality management and traceability, but identified some gaps in training and health and safety to meet nuclear industry expectations.

...aiming for a 50–60 per cent increase in turnover...

Driving growth: managing director Chris Batty.

"We saw nuclear as a future market that was worth developing"

"We won't have to have the health and safety culture you see on a nuclear plant, but we now have much more of an awareness of what nuclear culture entails," Batty notes. "It's been good to do it, and it's something we wouldn't have done unless we'd gone along this route."

The firm used team exercises to make sure that training was practical and engaging for staff and, with support from Pera, sent staff on joint training with two other companies. "They're not in our industry at all, but they were both manufacturers so we're doing a lot of the same things," Batty says. "It's opened our people's eyes – they found it really interesting to see other people's processes in a completely different kind of manufacturing."

Lestercast continues to invest in new capabilities, and is currently fitting out a new R&D centre with rapid prototyping and corrosion testing facilities. The firm has invested heavily in rapid prototyping and additive manufacturing, allowing it to supply one-off castings without the cost of new tooling, and to support customers during the design and testing of new products.

Lestercast is also working with Castings Technology International – one of the Nuclear AMRC's sister centres in the University of Sheffield's advanced manufacturing cluster – to develop techniques which can improve the surface quality of complex castings by replacing the traditional wax pattern with an additively-manufactured resin form.

Lestercast's sales and engineering teams are now working to better understand where the opportunities are in nuclear for relatively small precision castings, and seeking to build relationships with sub-contractors at tier three or four.

"We don't make a final product, we make bits that go into our customers' products such as valves or instrumentation," Batty says. "Because we're so new to nuclear, we're trying to understand where Lestercast is placed within the nuclear supply chain. There's still quite a lot of hard work for us from a sales and marketing point of view to understand where our market is within the nuclear industry, but we hope to be building our sales in this industry in the next 12 to 24 months."

With new business in nuclear and continued growth in its existing markets, Batty is aiming for a 50–60 per cent increase in turnover over the next five years.

"Nuclear is a market that's definitely going to expand in the UK over the next decade," he concludes. "And, from our experience, there are added benefits to be gained from the route we've gone through to be granted Fit For Nuclear that will help us in the other markets we supply."

lestercast.co.uk

F4N briefs...

Krantech has opened a new CNC machining facility to serve customers in the energy sector.

An established supplier of medium to heavy engineering and fabrication to subsea oil and gas, Krantech completed F4N in 2015. The new facility will allow the Chesterfield-based firm to take on work in new markets including nuclear and energy, and support in-house machining requirements.
www.krantech.com

Pressure vessel specialist **European Heathyards** is seeking new contracts and planning to create more jobs after completing F4N. The West Midlands firm has also opened a new high-security manufacturing facility to meet the stringent quality requirements of the nuclear industry.

"Adding another key market in which to secure new long-term programmes of work caps a very successful period for European Heathyards, and is a testament to the hard work, skill and dedication of our workforce," said technical director Arran Nash.
www.europeanheathyards.com

Fugro GeoServices is working with Horizon Nuclear Power and Atkins on offshore ground investigation for the Wylfa Newydd new build site. The project involves drilling 33 boreholes off the site on Anglesey. Fugro GeoServices completed the F4N programme in May.
www.fugro.com

Diffusion Alloys, the Hatfield-based provider of protective coatings against metal degradation, is targeting the civil nuclear supply chain after completing F4N.
www.diffusion-alloys.com

Plymouth-based **Fine Tubes** showcased its high-specification tubing ranges at the World Nuclear Exhibition in Paris. The firm has developed tubes for the nuclear industry since the 1970s, and is pursuing global opportunities after completing F4N in May.
www.finetubes.co.uk

Work **with us**

The Nuclear AMRC is here to support manufacturing companies, from SMEs to global giants, which are seriously interested in winning business in the nuclear sector.
If we can help your company, we want to hear from you.

We help manufacturers through **supplier development** and **innovation**.

We can work with you to raise your quality, capability and cost competitiveness to meet the needs of the global nuclear industry.

And we can develop world-leading manufacturing processes and technologies. We have the production-scale facilities and the manufacturing expertise to help you improve cycle time, reduce lead time, improve quality and reduce costs.

Our capabilities and services are open to all UK manufacturers. We provide a responsive service to help you solve your manufacturing challenges and win new work.

We also offer full membership, giving you access to our generic projects and the opportunity to determine our core research.

To find out more about how we can help your business,
contact Jay Shaw, Nuclear AMRC senior business development manager:
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