NUCLEAR AMRC news
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Disruptive **innovation**

New technology strategy focuses on creating value

CATAPULT
High Value Manufacturing

NUCLEAR AMRC

NATIONAL NUCLEAR LABORATORY

NUCLEAR INNOVATION UK CONFERENCE

R&D FOR THE NEXT GENERATION

2-3 July 2019, Sheffield

The Nuclear AMRC and NNL invite you to a major conference focusing on R&D supported by the Nuclear Innovation Programme.

Backed by the UK government, the **Nuclear Innovation Programme** is an ambitious multi-year research and development programme to develop the next generation of nuclear technologies. Projects cover a host of technology areas which will provide real commercial opportunities to companies in the supply chain for nuclear and other high-value sectors.

Join industry experts in nuclear power, digital manufacturing and R&D to discover the latest innovations, and learn more about the opportunities to come.

Key speakers include:

Dr Tim Stone
Nuclear Industry Association

Dr Fiona Rayment
Nuclear Innovation and Research Office

Allan Cook
High Value Manufacturing Catapult

Adriènne Kelbie
Office for Nuclear Regulation

For more information, and to book your place: **nuclearinnovation.co.uk**

If you have any questions, email: **niuk@namrc.co.uk**

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Insphere collaboration **brings innovation to market**

Innovative metrology company Insphere has launched its new rapid machine tool verification product, developed with the help of the Nuclear AMRC.

Innovation in action: delegates are shown the Baseline technology on the Nuclear AMRC's Soraluce.

Driving productivity: Insphere CEO Ben Adeline.

The Bristol company's Baseline technology can provide full verification of a large machine tool in less than one hour, facilitating regular checks and providing confidence in performance prior to cutting metal. It can reduce machine downtime and material scrap rates, and supports the move towards Industry 4.0 digital manufacturing philosophies.

Insphere launched the product to customers at the Nuclear AMRC in March, after working with the centre's metrology and machining team to test and develop Baseline on the Soraluce FX12000 machine. Capable of working on pieces of up to 12 metres length and five metres diameter, the Soraluce is the largest machining platform available for collaborative R&D in the UK.

"Our focus is on large machine tools producing high-value parts – we're trying to reduce the downtime associated with verification," Insphere founder and CEO Ben Adeline told delegates.

The event, which brought together around 35 engineers from industry and research institutions, included live demonstrations of the technology in action.

The Baseline system uses laser tracking technology, provided by Nuclear AMRC member Hexagon Manufacturing Intelligence, to create an accurate three-dimensional picture of the machining platform. Insphere's software controls the collection of measurement data while the machine tool runs a pre-planned path. The software then applies algorithms to assess performance and to evaluate kinematic errors in the linear and rotary axes.

The process takes between 30 and 60 minutes for a rapid "health check" verification of all axes and squareness. A full verification, including tests of the machine's dynamic response, can take from 45 minutes to two hours depending on the size and complexity of the machining platform. The system can also run a full ISO230 compliant test.

By allowing rapid identification of any problems, Baseline can improve productivity by enabling preventative maintenance before anything goes awry, minimising the risks of unexpected downtime, and reducing scrap. The data can also help integrate large machine tools into modern digital manufacturing systems.

"Our product philosophy is to develop the next generation of metrology products to enable Industry 4.0 manufacturing solutions," Adeline said. "We want to design an ecosystem of metrology products to drive productivity."

The Baseline development project was funded by the Aerospace Technology Institute through the National Aerospace Technology Exploitation Programme, and also included Hexagon Manufacturing Intelligence, Rolls-Royce and University of Huddersfield.

Speaking at the launch, Hexagon's Tim Gears introduced some of his company's new high-performance products for laser metrology including the Leica Absolute Tracker ATS600, which can locate a point to within 300 microns from 60 metres away, and the Leica Super CatEye reflector used in the Baseline demonstration.

The Nuclear AMRC's Simon Cavill also presented the centre's ongoing research into on-machine inspection and verification for large-scale machining and fabrication tasks.

inspherelt d.com

Flexible welding with new robot cell

Nuclear AMRC welding engineers are using a new robotic welding cell to investigate an arc technique which promises to cut cycle time while reducing the risk of distortion.

Cold metal transfer is a new kind of gas metal arc welding (GMAW) with a much lower heat input than conventional methods. Standard MAG techniques usually require a continuous feed of wire into the weld pool, creating a continuous arc which rapidly builds up heat.

The trick lies in the welding head, developed by Fronius, which moves the wire backwards and forwards several times a second, breaking the arc as soon as it forms. Allowing the weld to cool between each drop reduces the risk of component distortion. The technique can also eliminate spatter, reducing the need for post-weld clean-up or providing a high-quality clad finish.

"CMT offers low dilution and a high deposition rate – compared to laser or TIG welding, it's more efficient and economic, and can easily be automated," says Nuclear AMRC engineer Xiaoying Honey.

The CMT process was initially developed for welding thin sheets in the automotive industry, but is now finding new applications. It is ideal for steels, aluminium and galvanized sheets, and offers travel speeds of 400–500mm/min, compared with 100mm/min for TIG.

The Nuclear AMRC cell combines a Fronius TPS 400i welding system with an ABB six-axis robot arm and two-axis workpiece positioner.

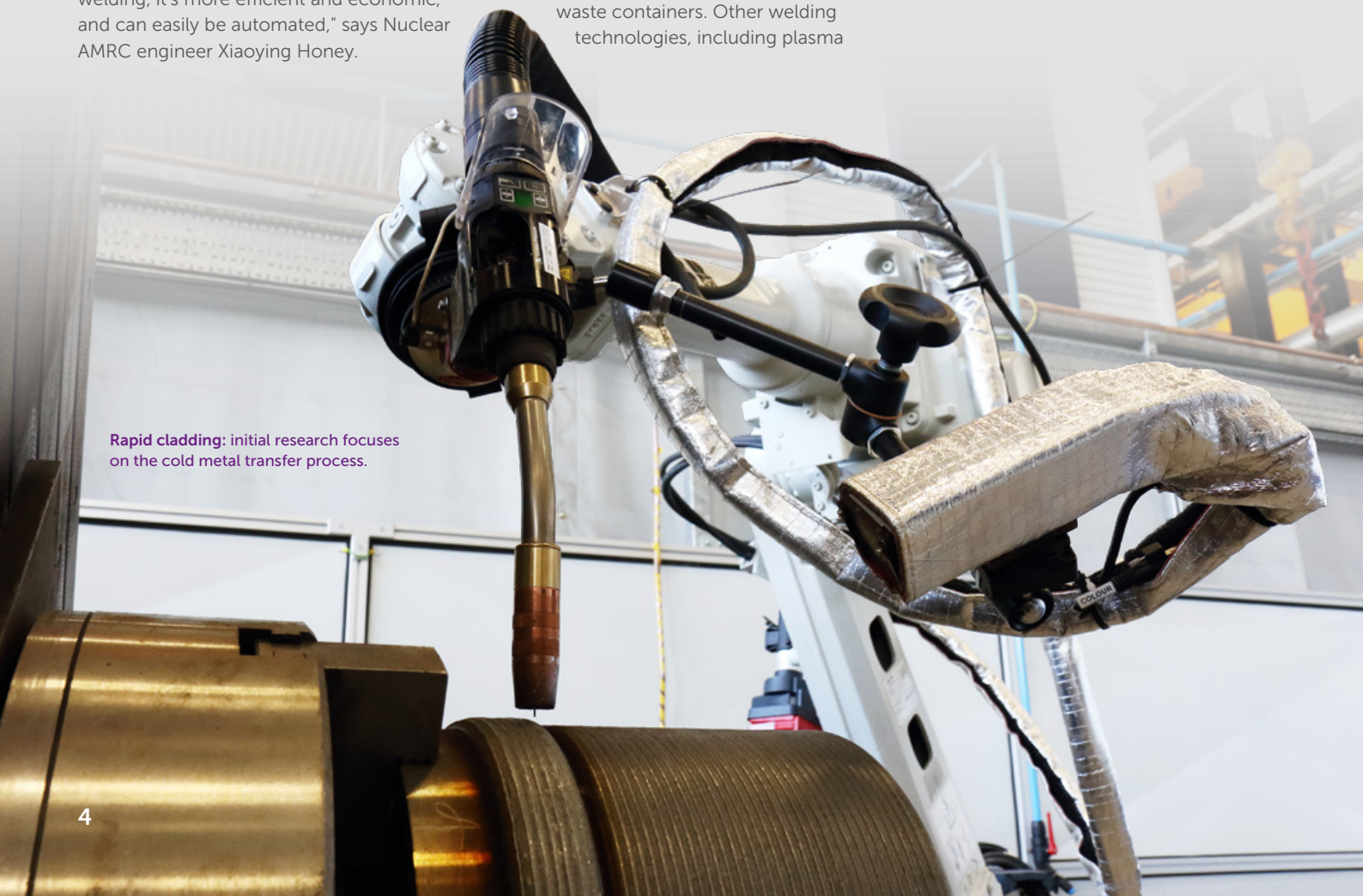
The team have completed initial cladding trials using CMT, and are now working on capability development projects alongside commercial research projects for nuclear and oil & gas applications.

The researchers will use the cell to develop automated welding techniques for high-volume products such as nuclear waste containers. Other welding technologies, including plasma and keyhole TIG, will be added to the cell to provide a comprehensive suite of automated arc capabilities.

"This will be a multi arc function cell," Honey says. "We already have TIG and plasma on a column and boom for large components, but if you want to do smaller trials then you want them on the robot cell."

The team will also develop tools for real-time weld process monitoring including laser seam tracking, to improve weld quality, and plan to investigate arc-based additive manufacturing techniques.

For more information about robotic welding R&D, contact: **xiaoying.honey@namrc.co.uk**



Rapid cladding: initial research focuses on the cold metal transfer process.

Gentle giant: the laser head is designed for high-speed welding of large components, but can also produce small fine joins.

Small heat exchangers present big welding challenge

The Nuclear AMRC worked with heat exchanger specialist Thornhill Group to demonstrate a new welding method for small tube-to-tubesheet assemblies which could halve cycle time.

The project called on the Nuclear AMRC's powerful disk laser welding cell, more often used on large components of up to three metre diameter. Using the laser on tubes measuring just 8mm diameter presented numerous challenges to the centre's engineers, who successfully demonstrated that large-capacity welding machines can be used for nuclear components of all sizes.

Thornhill Group is the only UK provider of the complete cycle of heat exchanger services encompassing design, engineering, installation, repairs and servicing for clients in power generation, oil & gas, chemical and other demanding industries. Headquartered in Yorkshire, Thornhill employs around 150 people across its three sites.

One of Thornhill's customers in the nuclear sector was looking to implement a tube-to-tubesheet joint within a restricted space, and asked the company to investigate how this could be designed and manufactured. To complement their own expertise in heat exchanger development and fabrication, the Thornhill team called on the Nuclear AMRC to help determine the feasibility of the customer's design.

The study for Thornhill was one of the first commercial projects for the Nuclear AMRC's disk laser welding cell, which was commissioned in early 2018. The cell was designed to develop high-speed welding techniques for large assemblies such as 3m³ nuclear waste containers, but is also capable of very fine narrow welds thanks to the high power density of the laser beam and fast travel speed of its gantry-mounted robot.

"Thornhill's heat exchanger was much smaller than the assemblies we usually work with, and right at the limit of what our robot and welding head can handle," says Dr Will Kyffin, head of the Nuclear AMRC's welding team. "The size and inertial mass of the robot meant that programming it to perform an accurate circumferential weld of just 8mm diameter was extremely challenging, especially as this was a new facility and the team were still finding out what it could really do."

The welding head had to be customised for the job, with the large gas nozzle and shield removed in favour of a separate gas shielding nozzle, and laser power was reduced to just 2kW from its maximum 16kW. Ensuring a high quality weld meant considering a host of factors, from angle and position of the weld head, to reducing the gas flow to avoid turbulence in the molten metal.

Initial trials showed that small tube-to-tubesheet welds could be successfully completed, with welding taking just over one second for each join. Allowing for movement time, a full tubesheet could be welded in a matter of minutes.

The project proved that a robotic laser welding cell can successfully join small tube-to-tubesheet assemblies, and the customer's design can be manufactured to requirements.

Thornhill presented their full manufacturing proposal to their customer, secure in the knowledge that it had been practically tried and tested.

"While our heat exchanger design and manufacturing expertise has been proven over many years in the nuclear industry as well as other industry sectors, this project presented unique challenges," says Sean Murphy, Thornhill's business development director. "Sourcing independent, authoritative data from the Nuclear AMRC, one of the world's leading research bodies in the nuclear field, on its feasibility was invaluable in presenting our solution to the customer."

thornhill-group.co.uk

University researchers take up residence

Two researchers are starting projects at the Nuclear AMRC supported by the Researchers in Residence programme.

Dr Simon Fletcher of the University of Huddersfield is developing new tools to improve machining accuracy for the largest components, while Dr Nicolas Larrosa of the University of Bristol is investigating additive manufacture for fusion applications.

Researchers in Residence is funded by Research Councils UK to improve knowledge sharing between university-based researchers and the industry-focused Catapult network, including the seven centres which make up the High Value Manufacturing Catapult.

Traceable on-machine inspection

Dr Simon Fletcher is working with the Nuclear AMRC to improve accuracy on the largest machine tools. His work focuses on developing embedded structural monitoring sensors and modelling techniques to compensate for errors caused by variations in temperature. In combination with innovative in-process verification techniques, the project aims to significantly reduce uncertainty in on-machine probing.

The project addresses one of the biggest challenges for high-precision machining of large parts, which stems from the simple fact that machine tools are typically made of metals and other materials which expand and contract with changes in temperature. From distortion of the machine structure to changes in spindle length, thermal effects can produce uncertainties of a millimetre or more in the tool position.

"Thermal variations can come from workshop temperature changes, and internal heat from the machine and machining processes," Fletcher says. "Whether it's a small variation on a daily basis, or a longer seasonal variation, it can all have an effect on the accuracy of the machine."

Fletcher has over 20 years of experience in improving machine tool performance, developing geometric error compensation techniques which are now standard practice, then moving on to thermal compensation.

Big machining challenges: Dr Simon Fletcher.

Addressing additive for fusion: Dr Nicolas Larrosa.

His current research uses a variety of on-machine probing and embedded structural monitoring tools, including a new generation of advanced strain sensors. Data from the devices will feed into physics-based numerical modelling and machine learning techniques using artificial neural networks, to provide time-dependent error prediction and correction to improve machine accuracy.

The project also aims to reduce the uncertainty of in-process measurement to a point where it can be used for traceable measurement on large machine tools and components.

"By improving the performance of the machine, you can start looking at whether the machine can perform measurements as well as accurate machining," he notes. "We aim to provide a comprehensive uncertainty budget which will be satisfactory for traceable measurement. Building that uncertainty model isn't trivial – for a CMM it's been developed over many decades, and we need to do the same for on-machine measurement."

The project will also tackle on-machine measurement of surface roughness. Many nuclear components have strict requirements on surface roughness, to minimise the risk of stress corrosion cracking in service, but large components can't simply be taken to a laboratory for measurement.

Fletcher will work with the Nuclear AMRC's machining and metrology team over four years to prove and scale up the technology. The team will install and test new sensors on the Soraluce FX12000 horizontal boring machine, and also provide large-scale metrology support with equipment including the Etalon Multiline laser measurement system and Renishaw on-machine probes.

Fletcher will also work with the centre's industry network of members and customers to ensure that his work meets industry requirements, and draw on data from other projects involving very large testpieces.

Fletcher's research will complement the Nuclear AMRC's

long-term investigation of in-process inspection on large machine tool platforms. "On-machine inspection is an extremely commercially attractive methodology for high-value components," notes metrology engineer Simon Cavill.

Additive manufacturing for nuclear fusion

Dr Nicolas Larrosa will work with the Nuclear AMRC to investigate additively manufactured vanadium components for potential use in fusion reactors.

Vanadium has long been used as a micro-alloying element in high-strength steels and titanium alloys. In its pure metallic form, or alloyed with a small amount of chromium and titanium, vanadium could be an ideal material for the internal components of a fusion reactor. It is resistant to neutron damage and can withstand the harsh temperatures, stresses and electromagnetic fields experienced in the fusion environment.

Potential applications include the divertor system, which removes waste from the plasma while the reactor is operating. Cladding techniques could also be used to add a functional layer of vanadium to steel structural components.

Producing reactor components by additive manufacturing (AM) – where the part is built up from powder or wire rather than being machined down from a solid billet – would allow reactor developers to create more efficient designs, reducing build costs and improving operations.

"Vanadium is very expensive and, with additive, you can achieve a near-net shape with very little scrap," says Larrosa. "You can also achieve very complex geometries which would be impossible using machining or other conventional techniques.

"However, AM parts are characterised by relatively low levels of repeatability and reliability due to a highly variable manufacturing process. Several initiatives were recently launched to benchmark and mitigate the uncertainty of structural properties in AM parts, but there is a notable lack of research on low and high temperature fatigue."

As with any safety-critical reactor systems, developers need to be sure that components produced using innovative techniques don't increase the risks of component failure. Larrosa's research aims to better understand the material properties of additively manufactured vanadium, particularly the mechanisms behind crack formation and propagation.

As a first step, Larrosa will work with two of the centres within the HVM Catapult to produce a series of samples made with different additive techniques. The Nuclear AMRC will produce samples using wire-fed arc and electron beam additive techniques, while the MTC in Coventry will focus on powder-based methods such as selective laser melting.

Larrosa will then subject the samples to extensive fatigue testing and analysis to identify which techniques are the most appropriate for fusion applications. "We will compare defects and the structure of how defects are embedded in the sample, and understand what the typical defect arrangement is, which will allow us to create better samples," he says.

AM microstructures are component-dependent, he notes, so a fundamental understanding of the effect of microstructural features on fatigue tolerance is required before AM components and structures can be used in safety-critical applications.

The 30-month project also involves the Culham Centre for Fusion Energy, Henry Royce Institute and University of Birmingham. Ultimately, Larrosa aims to develop engineering rules for the design and structural integrity assessment of additively produced vanadium components.

Working with the HVM Catapult provides access to a range of industrial partners, he notes, helping ensure his research is meeting industry needs.

"It gives me a widespread understanding of technology needs and how I can link structural integrity with manufacturing to add value to the final component," Larrosa says. "One of the main advantages of the Catapult is that it brings together academics like me and the final users. It's very applied research, and this gives us the opportunity to interact in a unique place."

catapult.org.uk/work-with-us/researchers-in-residence

The first researchers to work with the Nuclear AMRC through the Researchers in Residence programme, both from The University of Manchester, are now one year into their projects.

Dr Matthew Roy is developing more consistent methods for identifying and analysing residual stresses. He has shown that his open-source contour method software, pyCM, is capable of analysing benchmark components and real data with results as good as commercial finite element analysis (FEA) software.

"The Nuclear AMRC has provided a benchmark analysis and has been immensely helpful in sorting out bugs and helping to dictate what a model workflow would look like for this type of analysis. This ranges from physical cutting of the specimen, to metrology and finally to results," Roy says.

He is now analysing the results of the final trials at the Nuclear AMRC, and preparing a full release of the pyCM software.

Dr John Francis is working with the Nuclear AMRC's electron beam welding team to minimise the risk of crack propagation in nuclear pressure vessels. His research has focused on the potential influence of welding traverse speed on the toughness of electron beam welds.

The Nuclear AMRC team helped design and manufacture nine weld testpieces in 80mm thick pressure vessel steel, with varying welding speed and constant heat input.

Welding is now complete, and Francis is characterising the microstructures, residual stresses and toughness of the welded testpieces. The next phase of research will examine whether any negative effects of increased welding speed can be ameliorated by heat treatments.

Government advisors urge investment in advanced nuclear technologies

The UK government's nuclear innovation advisors are recommending a £1 billion, five-year investment in advanced nuclear technologies to help meet the country's clean energy commitments.

The recommendation comes in an annual report from the Nuclear Innovation and Research Advisory Board (NIRAB), its first since being reconvened in 2018. NIRAB brings together around 40 leading nuclear professionals from industry and academia to advise government on publicly-funded research, and is chaired by former Nuclear AMRC chief executive Mike Tynan.

To meet the requirements of the UK's 2017 Clean Energy Strategy, the report urges government to work with industry to define a roadmap for future nuclear new build. A sustained cost-competitive programme of new reactors is needed to meet legal targets for decarbonisation, including current Gen III+ designs as well as new kinds of advanced and small modular reactor. Early involvement will create significant opportunities for job creation and economic growth for the UK.

Government support for demonstrating advanced reactors is essential for attracting and enabling the necessary level of private investment, the report notes, and government should invest alongside industry to facilitate an advanced nuclear technologies programme capable of delivering an operational reactor by 2030.

The government is currently investing in new nuclear technologies through the Nuclear Innovation Programme, with £180 million committed from 2016–21. The report highlights a few case studies from the current phase of the programme, including projects led by the Nuclear AMRC to develop tools which could halve the production time and cost of large complex components such as pressure vessels.

Over the following five years, NIRAB recommends that the government invest around £1 billion in key programmes. This includes around £600 million in advanced nuclear technology demonstration, £300 million in research to develop key UK capabilities and align the supply chain to market opportunities, and £100 million in critical infrastructure to support prototyping and demonstration of new reactor concepts.

International collaboration is vital for the UK to play a significant role in commercialising advanced nuclear technologies, the report notes. NIRAB recommends that the government establishes an effective international strategy, and reviews the impact of Brexit on UK nuclear programmes once the new arrangements become clear.

www.nirab.org.uk

Research highlights

Some recent publications by Nuclear AMRC researchers

A new data-segmenting method for measuring complex features on a CMM could significantly cut programming time and reduce uncertainty.

Rather than considering features such as tubesheet trefoils as a set of discrete data points, the technique breaks them down into a series of continuous segments which can be efficiently measured with a scanning probe.

Initial trials led by Dr Feng Li reduced measurement time by more than 90 per cent compared with traditional touch-trigger probe methods.

The research was funded by the HVM Catapult, and is published in the *International Journal of Computer Integrated Manufacturing*.

doi.org/10.1080/0951192X.2019.1599431

A combination of supercritical carbon dioxide coolant and minimum quantity lubricant can improve tool life by 324 per cent. Milling trials with 304L stainless steel, carried out on the Nuclear AMRC's Starrag HEC1800, found no significant differences in residual stresses or surface microhardness. The lubricant consisted of just one millilitre per minute of soybean oil, dissolved in the CO_2.

The research, part of an ongoing development programme led by Dr Krystian Wika, was supported by the HVM Catapult and published in *Wear*.

doi.org/10.1016/j.wear.2019.01.103

Executive **view**

We need to work as one to drive innovation

With the government's climate change advisors urging a quadrupling of low-carbon electricity production by 2050, nuclear power must play an important role at the heart of the UK's energy mix.

It's easy to feel that we have been here before. Over ten years ago, the UK planned a nuclear renaissance to replace the current fleet of power plants, but during this period there have been various challenges that have either delayed or hindered that ambition. Nevertheless, we still believe the nuclear ambition remains the same.

Now, attention is focusing on new designs of small modular reactor (SMR) and advanced modular reactor (AMR) which could be delivering electricity to the grid by the mid-2030s.

A government announcement on support for SMR development is overdue but, in the meanwhile, the Nuclear Sector Deal offered quite significant funding for research and development into the next generation of AMRs. This covers a range of innovative technologies, from salt-cooled reactors to small fusion tokamaks. Here at the Nuclear AMRC, we are already engaged with most of the developers, and hope to hear shortly from government about which designs will be taken forward to the next development stage.

Turning any of these designs into commercial reality will take a huge amount of work, of course. Any reactor needs to be commercially viable, and effort is needed to drive down production costs and reduce the time to electricity generation.

We are already developing the manufacturing technologies to make that happen, through a host of collaborative projects including those funded by government through the Nuclear Innovation Programme (NIP). We are leading research into single-platform manufacturing, and tackling challenges in high-precision fabrication of pressure vessels and other large components. We are also working with industry partners on other projects in the advanced manufacturing and materials stream of NIP, addressing shared challenges such as modularisation, advanced joining and materials evaluation.

Alongside this, NIP is supporting some very exciting research in areas such as digital reactor design – where we're working with Wood to integrate manufacturing data into digital models – advanced fuel development and recycling, and thermal hydraulic testing.

You can find out more about all of these projects at the Nuclear Innovation UK conference in July, hosted by ourselves and NNL. This is a great opportunity to discover the work that's been completed in the first phase of NIP, and find out how you can get involved with the future of the programme. With the Nuclear Innovation and Research Advisory Board proposing a further £1 billion investment in advanced nuclear R&D by 2026, there will be major opportunities for companies to develop new capabilities and disruptive technologies.

Manufacturing innovation and supply chain development will be really important factors in quadrupling low-carbon electricity in a cost-effective way, and we have a key role to play in making this happen. As you'll read in the following pages, our new technology strategy is designed to ensure that we are meeting industry needs, and linking our R&D more closely with our supply chain development programme to deliver real business benefits to UK manufacturers of all sizes.

The Nuclear Sector Deal set out how we can work together to transform the industry, but we still need to implement its ambitious proposals. The Nuclear Industry Council has established the structure to help deliver the various parts of the deal, and I'm really pleased to lead the Winning UK Business working group. We have a fantastic group looking at the global opportunities and, if we can harness a Team UK approach, I am confident we can grow our export market. It is a commercial business after all, but we do need to come together if we really want to tackle the challenges that affect us all.

We have all seen and read the news recently about the environment. It is great that more attention is being paid to this. Delivering low-carbon energy for generations to come demands bold thinking and new ways of working, and I hope that the government will set out bold steps in the upcoming energy white paper to ensure we act positively.

I encourage you to come to the Nuclear Innovation UK conference; you will hear some provocative ideas from key industry figures on what we need to do to really deliver on the promise of new nuclear technologies.

The necessary move to net-zero emissions will require massive investment and disruption to established ways of working, and the opportunities for manufacturers could be huge. We're here to help you make the most of them.

Andrew Storer, Chief Executive Officer, Nuclear AMRC

Developing new technologies

to meet industry needs

The Nuclear AMRC is expanding its technical capabilities to better meet the current and future needs of the UK nuclear industry. The centre's CTO, Professor Steve Jones, introduces the new technology strategy.

Chief Technology Officer: Professor Steve Jones.

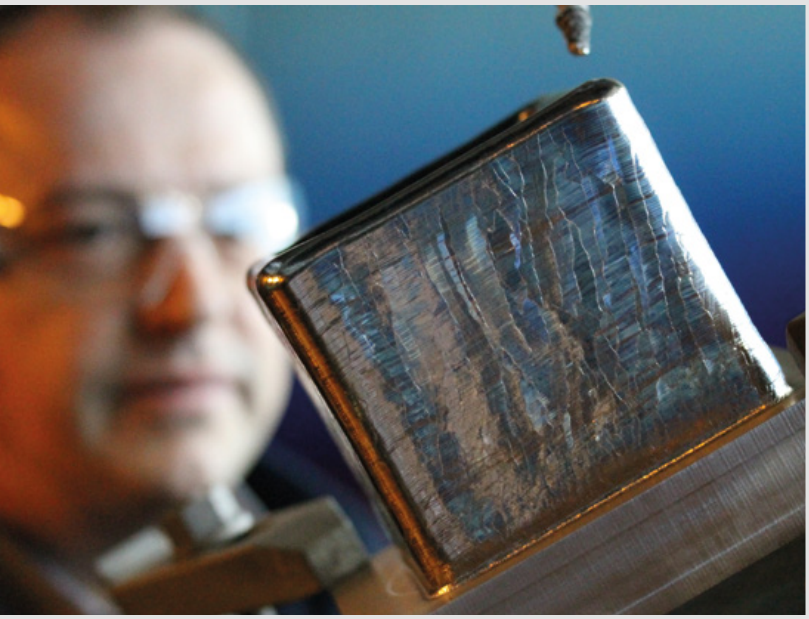
When the Nuclear AMRC was first conceived a decade ago, its focus was on providing metals engineering expertise to the UK supply chain. That mission was driven by the requirements of a few leading industry partners as we collectively embarked on an ambitious national new build programme.

It's fair to say that the nuclear market has seen some changes since then. From the global pause following the Fukushima incident, to the recent decisions by Hitachi and Toshiba to withdraw from their UK new build projects, the nuclear renaissance has failed to gain the hoped-for pace. At the same time, we've seen increasing cost pressures on the UK's decommissioning programme.

When we recently took stock of where we were, it became obvious that the skills and capabilities we have within the Nuclear AMRC can be equally relevant to other parts of the nuclear landscape. We can drive innovation from decommissioning and waste management to next-generation modular reactors and new fusion technologies, as well as in other technically demanding high-value sectors such as offshore renewables, oil & gas, defence and aerospace.

We are still a young centre, and to reach our full potential we need to expand our remit beyond our original focus on metals manufacturing, into new areas such as control and instrumentation, construction, digitalisation and equipment qualification. We need to offer whatever support UK manufacturers require to win work in our core markets.

Our new technology strategy sets out how we can grow our people, skills, capabilities and facilities, and more closely align our



Anchor **technology themes**

These nine core technology themes can deliver the maximum value from targeted development for the nuclear new build, operations, decommissioning and naval sectors:

- **Machining technologies** – new and optimised processes for the machining of large and complex components.
- **Joining technologies** – mechanised welding and solid-state bonding methods, including arc, power beam and diffusion bonding techniques.
- **Additive manufacturing and near-net shape forming** – high-integrity production and customisation of large metal components.
- **Automation and digitalisation** – robotics, artificial intelligence and data-driven manufacturing to improve productivity and develop new capabilities.
- **Controls and instrumentation** – digital sensors, instruments and safety systems for nuclear power plants and other industries.
- **Analysis and simulation** – high-fidelity data-driven models for processing and materials optimisation, plant construction and operations.
- **Material, surface, corrosion and thermal engineering** – enhanced material characteristics and performance in reactors and other extreme environments.
- **Product and process verification** – developing high-quality structural integrity data for performance models and through-life maintenance forecasts.
- **Codes and standards** – ensuring innovative manufacturing techniques meet relevant industry standards.

innovative R&D with our supply chain development programme to reduce costs and barriers to entry for companies of all sizes.

Our strategy is based around nine anchor technology themes (see above) which are of critical importance to the nuclear supply chain. These build on our established expertise in machining and welding technologies, and bring us into some very exciting new areas. We are already developing new capabilities at our modules R&D facility in Birkenhead and the new Nuclear AMRC Midlands in Derby, and will continue to invest in our established centre in Rotherham.

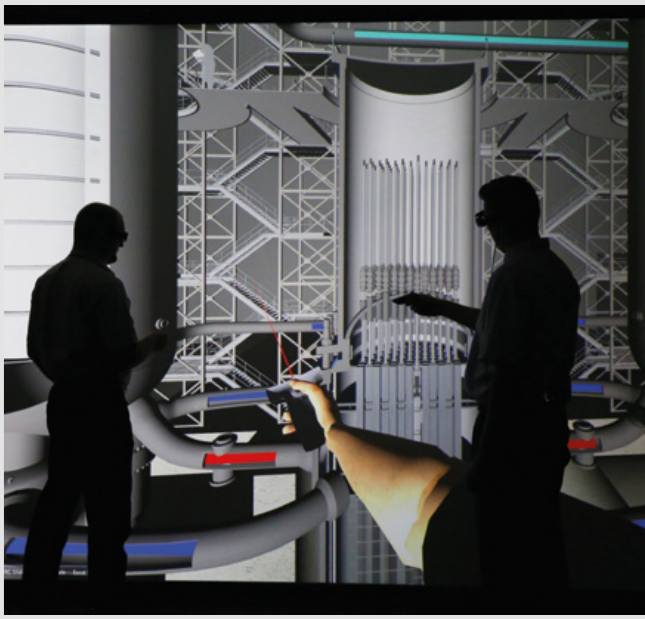
Cutting across these technologies are seven critical development programmes (see over), from automation and modularisation to through-life engineering services, which aim to reduce manufacturing costs and increase productivity and performance across a host of applications.

In part, these build on some of our recent collaborative R&D projects into topics such as single-platform manufacturing, intelligent robotic systems and SMR pressure vessel manufacturing. These projects have helped us build robust technological proposals for our future growth, based on a strong and agile manufacturing philosophy aligned with industry requirements.

Meeting industry needs

We continue to consult with companies of all sizes to produce strategic roadmaps across these technologies and development programmes, and always welcome input from manufacturers and technology developers.

Our research board of member companies



plays a vital role in ensuring our strategy is aligned to industry needs. The research board meets four times a year, bringing together technical leaders from our members and key stakeholders to make sure that all our R&D is delivering real value to industry, while also providing research excellence impact for the University of Sheffield.

While we are always open to all companies, we work most closely with our members to tackle shared challenges. As well as guiding our overall research activities, the board identifies areas of shared interest where generic research can be funded from the pot of members' financial contributions. Members can also fund more targeted projects from their individual membership funds.

We aim to balance our research, development and deployment across the full range of manufacturing readiness levels (MRLs), providing a healthy balanced tension between technology push and industry pull.

We will invest around a quarter of our budget into relatively early-stage research (MRL 2–3), taking emerging technologies from universities and research organisations and testing them against industry needs. Our core funding from the High Value Manufacturing Catapult underpins this vital stage of innovation.

Around 45 per cent of our budget will be targeted at the development stage (MRL 4–5), producing proof-of-concept prototypes of innovative processes or technologies. And the final 30 per cent will tackle the challenges of deployment (MRL 6–7), with full-scale demonstrators or introduction to a customer's own production facility.

To make sure all our work meets industry needs at all stages of development, we have devised an algorithmic approach to identify the technologies and research proposals which offer the greatest impact. This "figure of benefit" process produces a single value based on 11 key criteria, including the expected increase in MRL, relevance to the nuclear supply chain, expected return on investment, and value of resulting intellectual property.

Delivering the sector deal

Since the publication of the Nuclear Sector Deal last summer, we also review our work to make sure that our projects are able to contribute to the industry commitments to reduce costs and grow exports.

The sector deal also sets out initial support for new reactor technologies, which will be vital to the future of the industry and to our future as a centre. We will continue to develop strong links with the technology developers who are aiming to deliver the new generation of small and advanced modular reactors to the grid by the early 2030s.

As a centre, we are uniquely positioned to support these developers and their key suppliers in tackling the technical challenges – notably, those around developing, fabricating and modelling large components in heat-resistant and corrosion-resistant steels.

In parallel with this R&D, our supply chain development team are working with our members and Fit For Nuclear companies to ensure that the UK manufacturing industry is strategically aligned to and aware of the opportunities in these new programmes, and operationally fit to meet the needs of the global market.

I believe that if we are to succeed, we need to move beyond old principles of silo manufacturing, and look at shared challenges and solutions. If we only acquire advanced technologies for isolated applications, we will rapidly find ourselves in a dead end of inefficiency and technological redundancy.

We need to integrate emerging concepts with proven technologies. Developing and procuring such technological solutions will allow the UK supply chain to succeed in all parts of the nuclear sector, and allow us to transfer technologies into and out of other high-value industries while leapfrogging our international competitors.

Our aim for the Nuclear AMRC is to be first for nuclear, producing cost-effective technological solutions and maximising impact for our customers and stakeholders. Wherever you sit in the supply chain, we want to support you.

Critical development programmes

These seven R&D themes cut across our portfolio of technical capabilities, and underpin the adoption of new manufacturing technologies for the nuclear industry:

- **Automated platform manufacturing** – game-changing productivity improvements by completing multiple manufacturing and inspection processes on a single centre.
- **Equipment qualification** – providing assurance that power plant components and assemblies meet all design standards and specifications.
- **Modularisation** – fabricating large plant systems in factories rather than assembling on-site, including design for modularisation.
- **Reconfigurable tooling & smart facilities** – flexible data-driven tools to deliver a wider variety of manufacturing, assembly and inspection processes.
- **Standardisation** – improving productivity by making sure different facilities and components work seamlessly together.
- **Supply chain development** – identifying opportunities and closing potential gaps in the UK supply chain, working through our established Fit For Nuclear programme.
- **Through-life engineering services** – creating new market opportunities and ensuring the long-term performance of complex safety-critical systems.

Continuing impact from Fit For Nuclear

The latest survey of manufacturers taking part in Fit For Nuclear shows that most are confident of winning new nuclear work in the next 12 months, despite growing gloom and uncertainty about the general economic climate.

A fifth of the companies who reported demonstrable business benefits say they have already won new orders in nuclear. In all, 85 per cent of participating companies would recommend Fit For Nuclear (F4N) to other manufacturers.

F4N is a unique service which lets manufacturers measure their operations against the standards required to supply the nuclear industry – in new build, operations and decommissioning – and helps them take the necessary steps to close any gaps. F4N is delivered exclusively by the Nuclear AMRC, and supported by top-tier partners in nuclear new build and decommissioning.

More than 730 UK manufacturers have now taken the initial F4N online assessment, with most receiving ongoing support from the Nuclear AMRC's industrial advisors. Ninety per cent of the 92 companies who responded to the survey are small and medium-sized enterprises (SMEs).

Completing the journey from first assessment to granting typically takes 12–18 months. A fifth of respondents said it was too soon to report demonstrable benefits but, of the others, most said they had experienced demonstrable benefits from improvements in HSEQ measures to new orders and new connections with nuclear buyers.

Views on the economic climate over the coming year were notably gloomier and more uncertain than previous surveys, with many respondents citing Brexit. But 78 per cent expect their turnover to grow in the next year, with 53 per cent confident of winning new work in nuclear.

New entrants to the nuclear supply chain say they face significant obstacles to winning work – 61 per cent of respondents said that connecting with potential buyers was one of the biggest challenges, and 52 per cent said they lacked awareness of opportunities.

The survey results will be used in the continuing development of the F4N service to provide additional value to manufacturers.

The programme received a major overhaul in late 2017, providing additional support to companies after granting and launching the F4N Connect portal as a fully-searchable showcase for granted companies.

A three-year time limit to certification was also introduced, with many established F4N companies now going through re-assessment before being granted for another three years. Of the survey respondents, 17 per cent were currently being re-assessed.

Suggestions for further developing the service included additional support to address factory floor issues, and events or services to promote engagement between granted suppliers and nuclear buyers.

Start your F4N journey:
namrc.co.uk/services/f4n

What manufacturers say about F4N

"We cannot fault the support and enthusiasm from all the members of the F4N programme in the last couple of years of working together."
Lisa Randall, Diffusion Alloys

"I have always been a big advocate of the F4N programme and believe that the support provided to improve businesses is fantastic. However, the nuclear sector is a difficult market to penetrate. The government wants more SMEs to work in the nuclear sector, but does the sector actually want them?"
Roger Kimber, Strata Technology

"F4N is in itself a great programme – if it can gain greater international acceptance that would be good, and any links to the new international standard (ISO 19443) will be welcomed."
Clive Odell, Turnell and Odell

"The journey never ends, and we have only become a much better company due to F4N and our commitment to continually improve."
Tanya Brennan, Polycast

F4N
Fit For Nuclear

TP Group on track to double nuclear business

TP Group's Advanced Manufacturing Centre in Manchester is winning major nuclear contracts after securing Fit For Nuclear status and investing in new capabilities.

Tools for the job: TP Group's Hankook vertical turning centre helped deliver a major nuclear contract.

An extended contract with Baker Hughes GE, worth around £6.4 million, came as the company renewed its F4N status following a comprehensive re-assessment of its operations.

TP Group's heat exchanger factory in Dukinfield was originally granted F4N in 2015. Under its former brand of Hunt Thermal Technologies, the business then aimed to improve its production performance, move up the value chain, and grow in nuclear.

The company secured a £1.5 million nuclear contract from Baker Hughes in late 2016. Fulfilling the contract required investment in new machining capabilities, and TP Group worked with the Nuclear AMRC and member company TW Ward to identify the best machines for the job.

Darren Sadler joined the company in early 2017 to lead engineering operations and manage installation of the new Soraluce mill-bore centre, Hankook vertical turning lathe, and the further development of the group's Advanced Manufacturing Centre. The new facility, including a high-capacity Global CMM from Hexagon Manufacturing Intelligence, officially opened in February 2018.

"As people started to hear that we have these machines, we have seen new work from other companies working in nuclear and other sectors," Sadler says. "We've became known as a good source of one-off components where tolerances and quality are critical. We're also doing a lot more work in-house because of the machines and approvals we've now got."

While some of the new work is for other kinds of component, the company continues to focus on heat exchangers and thermal systems for increasingly demanding applications. "Nuclear is a highly demanding industry. We've not just moved from heat exchangers for oil & gas to heat exchangers for nuclear – it's several levels up in terms of quality," Sadler notes. "It's moved from tolerances of 2mm to tolerances of 0.2mm. The requirement in machining capability is significant to get us to the point where we can offer what the customer is asking for."

The F4N badge is granted for a period of three years, and TP Group came up for renewal shortly after opening its Advanced Manufacturing Centre. The team who had managed the original granting had since left the business, and responsibility fell to Sadler and new colleague Phil Carter from the business development team.

F4N advisor John Olver eased the new team's journey to re-granting, helping them ensure that all aspects of operations – from metal segregation and traceability to internal communications processes – met the latest F4N standards.

"The new forward-thinking management team really grasped the opportunities of their F4N renewal to undertake a root and branch review of all the business processes and procedures," Olver says. "Crucially, they made improving communication at all levels a key priority, and their explanations of the need for change and continuous improvement ensured an enthusiastic response from what had previously been a fairly traditional workforce. TP Group is a great company which is seeing strong growth in nuclear, and creating much-needed skilled jobs."

The team say that Olver brought a wealth of experience to the assessment. "It was like it started again from scratch, but John's input was a massive help," Sadler says. "He's seen it all before, and he's very thorough with what he sees when he walks around. The people here soon started to understand where John was coming from."

Around a tenth of revenue at the Dukinfield site now comes from nuclear, including ongoing work for EDF Energy's operational reactors.

The company is aiming to further increase its footprint in nuclear, says Carter, while continuing to serve its core market in the resurgent oil & gas sector. "We aim to double what we're doing in nuclear over the next three to five years," he says. "There is more money in nuclear once your infrastructure is in place, but it's such a slow process compared with oil & gas. We're talking to customers about orders that may come in seven years."

The new contract from Baker Hughes, announced in January, will be delivered over the next five years. The long-term nature of nuclear contracts does help the business to plan and develop its staff, and TP Group is currently recruiting an additional 15–20 people to the 60-strong team at Dukinfield.

New capabilities: the new Advanced Manufacturing Centre opened in 2018.

"That is down to nuclear projects," Sadler notes. "When you've got work beyond 12 months, you can plan a lot further ahead, and that allows more stability in staff".

The company has now joined the National Skills Academy for Nuclear to ensure that all the team are suitably qualified to build on the company's renewed F4N status.

"We are seeing customers asking for F4N – it's like a prerequisite for a lot of things we're seeing," Sadler says. "It's all about what we do on the nuclear side, but if we get that right we can float it out to other areas. Oil & gas is becoming a lot stricter and more critical in documentation and materials. Process is everything, and that's one of the things that John says a lot – that things have to be right, not just looking right."

www.tpgroup.uk.com

Congratulations to the latest companies to be granted Fit For Nuclear

These companies have benchmarked their performance against the standards demanded by the nuclear industry's top tiers, and driven business improvements.

Crowle Wharf Engineers specialises in safety-critical engineering solutions for the power, steel and rail industries.
cwelimited.com

Harry Major Machine UK specialises in designing and manufacturing automated part-handling systems, assembly machines, and special machines.
www.harrymajormachine.com/harry-major-uk

Joseph Ash Galvanizing specialises in steel finishing services including galvanizing, spin galvanizing, shot blasting and powder coating.
www.josephash.co.uk

Congratulations also to the F4N companies which have renewed their status three years after initial granting.

Hydrobolt manufactures special fasteners and machined parts for use in critical environments, fully traceable and tested to nuclear standards.
www.hydroboltgroup.com

Oldham Engineering provides fabrication, welding, machining, refurbishment and turnkey projects for nuclear decommissioning and new build.
oldham-eng.com

Truturn Precision Engineering is a precision-engineered turning and milling company supplying the oil, gas, aerospace, nuclear and defence industries for over 30 years.
www.truturn.co.uk

New group focuses on **winning UK business**

A new industry-led group aims to tackle the challenges of winning more nuclear business for the UK supply chain.

The Winning UK Business group was set up by the Nuclear Industry Council (NIC) as one of five working groups to help deliver the Nuclear Sector Deal. Announced in June 2018, the sector deal is an agreement between government and industry which sets ambitious targets to drive down costs and improve productivity across the civil nuclear sector.

The working groups are aligned with the five overarching objectives of the sector deal, including reducing costs in new build by 30 per cent and in decommisioning by 20 per cent; developing the future workforce; and delivering R&D to support future nuclear programmes.

The initial objective for the Winning UK Business group is to build the capability and capacity of the UK supply chain to secure £2 billion worth of new contract wins.

The group, which has so far met twice, brings together around 20 senior professionals from industry, research and government and is chaired by Nuclear AMRC chief executive Andrew Storer. Adam Bond, government account manager at the centre, is also a member.

"Winning UK Business is all about improving how the sector organises itself and works collectively, including with government, to ensure the UK wins a bigger share of the nuclear market – both domestic and overseas," Bond says.

"The UK has exceptional capabilities and a proud heritage in this field, but nuclear is heavily controlled or owned by national governments. We therefore need to re-think how we approach domestic and overseas markets, in partnership with the UK government, and help the supply chain to make improvements in areas that we know will have greatest impact in terms of our ability to win work."

The group will oversee progress on the £30 million supply chain programme proposed by the sector deal, and link with advanced materials and manufacturing research funded by the Nuclear Innovation Programme.

Other initial activities for the group include an assessment of how the UK government can best support industry needs; identification of future export campaigns; and a review of how to best promote the offer and strengths of the UK nuclear supply chain.

www.gov.uk/government/groups/nuclear-industry-council

Taking UK expertise **to the UAE**

The Nuclear AMRC's supply chain team has completed a pilot project in the United Arab Emirates to demonstrate how UK expertise can help support the new nuclear plant at Barakah.

The nine-month collaboration was based on the Fit For Nuclear programme, with the F4N team guiding six UAE manufacturers through the early stages of assessment and support.

All six companies – engineering group Adyard, electrical specialist Ducab Cables, machining and fabrication group Rainbow Mechanical Solutions, sealing specialist Flexitallic, valve manufacturer Samamat, and power sector manufacturer Global Transformers – have extensive experience in the oil & gas and energy markets but are new to nuclear.

"The six manufacturers we worked with were all dedicated to the programme, and were great examples of the calibre of companies in the UAE," says Anna Boland, who managed the project for the Nuclear AMRC.

The project was a collaboration with the Emirates Nuclear Energy Corporation (ENEC), which is building four Kepco APR1400 reactors at Barakah in the west of the country. The first unit is scheduled to begin operations by early 2020.

The Nuclear AMRC team also worked with local partners including Nawah Energy Company, Khalifa University, Doosan Babcock and Atkins, with support from the UAE Department of Economic Development and UK Department for International Trade (DIT).

The results of the pilot project were presented to stakeholders in Abu Dhabi in March, with proposals for a full supply chain development programme now under consideration. The team also proposed other mechanisms to support the UAE supply chain, including a collaborative UK-UAE programme of advanced manufacturing research and skills development.

Delivering value: UAE stakeholders hear results from the pilot project.

"This is a great example of how we can use our domestic experience to foster international collaboration, and help create new opportunities for UK companies to export their own expertise," says Boland. "We will continue working closely with DIT in the UK to ensure the relations built during this project are maintained."

For more information about opportunities in the UAE, contact: **anna.boland@namrc.co.uk**

Sellafield visit highlights supply opportunities

In April, a Nuclear AMRC team toured Sellafield to better understand the decommissioning challenges across the site. Phil Jardine reports on the visit and the opportunities for suppliers.

Since plutonium production began at the site in 1947, pioneers at Sellafield have designed and built the world's first commercial-sized nuclear power station; recycled nuclear fuel to recover and reuse both plutonium and uranium; and created safe treatment and storage options for all types of nuclear waste.

Today, the site presents one of the world's most significant environmental remediation challenges. Covering two square miles and operating around the clock, Sellafield is home to four of the biggest nuclear risks and hazards in Europe.

Our visit, hosted by Sellafield's CTO Duncan Steel and head of its strategy and technical portfolio Kevin Burns, gave us a great deal of insight into the challenges and opportunities for UK manufacturers. Sellafield Ltd currently spends around £1.2 billion a year in the supply chain and, under the Nuclear Sector Deal, is aiming to reduce decommissioning costs by 20 per cent by 2030. Innovative technical solutions and reliable delivery from suppliers will be vital to achieving that target.

Our first stop was the viewing gallery of the Thermal Oxide Reprocessing Plant (Thorp), where spent fuel is transferred into containers which will be stored underwater for decades until the planned Geological Disposal Facility (GDF) is operational. We saw a selection of products, including high-level vitrified product and uranium containers, which will form part of the upcoming High Integrity Stainless Steel Container procurement.

From a modern facility to an old one: we next visited the Pile Fuel Storage Pond, built in the 1950s as part of the race for atomic weapons. This is a large open-air spent fuel storage pond and decanning facility. There are around 190 fuel skips in the pond, and the Sellafield team aim to remove some 130 by next year.

Because the pond is open-air, its base is covered in organic sludge. This is now being vacuumed out, and transported in shielded containers to the Waste Encapsulation Plant for mixing with a cementitious grout in 500-litre drums. These drums are then placed in a shielded store, pending permanent disposal in the GDF.

As part of the preparatory work for the dewatering of two inlet bays, we saw remote operated vehicles being used to monitor the underwater cleaning of structural steel. The dewatering of these bays will provide valuable information to aid the complete dewatering of the pond, before the team tackles the other three remaining open-air ponds. There will be opportunities for the supply chain to provide pumping equipment for the job.

We next visited the Waste Encapsulation Plant, which was commissioned in 1994 to deal with waste from Thorp. It was initially envisaged that the plant would cease operations this year at the same time as Thorp, but it will now remain open at least until the Pile Fuel Storage Pond is dewatered and its sludge safely encapsulated. Operational spares, product containers and cementitious powders will be procured during 2019. Sellafield is also working with a number of research partners, including the University of Sheffield, to develop a suitable geopolymer alternative to cement.

Our last stop was the Interim Storage Facility. This plant is a real success story for Sellafield and the UK, delivered millions of pounds under budget and months early. The store will take self-shielded cast iron waste boxes, supplied by our member Westinghouse.

The clear message we took from the visit is that this is an extremely challenging decommissioning programme, with a long-term future that has to provide value for money to the UK taxpayer and deliver significant cost savings in line with the sector deal.

While the challenge is to reduce hazards, demolish facilities and safely steward nuclear materials, the construction of treatment plants and storage facilities present good opportunities for many of the companies we work with at the Nuclear AMRC – particularly those who have been granted Fit For Nuclear.

For more information about opportunities in decommissioning, contact: **philip.jardine@namrc.co.uk**

Sparking interest at the Big Bang Fair

In March, three of the Nuclear AMRC's young engineers visited the Big Bang Fair, the UK's largest event for aspiring scientists and engineers. Ben Pamment reports back.

Held over four days at the NEC in Birmingham, the Big Bang Fair is the UK's largest event for promoting the STEM subjects of science, technology, engineering and maths. It brings together some of the UK's largest employers with students of all ages through a variety of activities, including hands-on demonstrations and competitions.

The Nuclear AMRC shared a stand with the Nuclear Industry Association (NIA). As well as educating our young visitors about the benefits of nuclear power, we were able to demonstrate two of our innovative areas of research – virtual reality (VR) and additive manufacturing.

We demonstrated our virtual model of our factory and talked about the work we do with VR, as well the latest developments with the technology in the field.

VR was the biggest pull of our stand, with a lot of enthusiasm about the technology from the kids. They had many questions about what the future of the technology could hold, and we got them engaged in thinking about engineering by asking them what they would use the technology for, if they were engineers.

Where it all begins: inside the Big Bang Fair.

Some of the more engaged students were also fascinated by our additive manufacturing examples, especially once they understood it as 3D printing with metal.

I believe the best way to engage younger generations is through hands-on activities. My own engineering career started by playing with Lego and dismantling electronics, and developing an interest in how things work. Events like the Big Bang Fair are an excellent opportunity to provide that kind of experience, and help translate initial interest into a career in engineering – especially important as the UK and the nuclear industry are facing acute skills shortages.

For those children who are interested in STEM, events like this can stimulate greater interest in engineering, and fan the flames of creativity that will lead them to become the problem-solvers of tomorrow.

www.thebigbangfair.co.uk

Rahul helps students get up to speed

Dr Rahul Mandal, Nuclear AMRC researcher and Great British Bake Off winner, brought the science of baking to South Yorkshire's annual Get up to Speed with STEM event.

More than 3,000 school students and 90 businesses attended the event, held a few miles from the Nuclear AMRC at the Magna science adventure centre in Rotherham. First run in 2011, the one-day event features a mix of interactive attractions and presentations from some of the UK's most innovative companies.

This year, Mandal gave a talk about the links between engineering and baking, with demonstrations.

"It was really great to be invited to be part of such a fantastic day, and to be asked to do a demonstration that makes that connection between science and baking was a big honour," he says. "The idea was to show young people that baking is science and that the kitchen is a lab to make delicious experiments, and that we do science and engineering in our everyday life."

As one of the Nuclear AMRC's STEM Ambassadors, Mandal regularly visits schools and takes part in other initiatives to encourage young people to develop careers in science and engineering.

He also recently featured in the #HumansOfSTEM Instagram campaign, which highlights inspiring individuals involved in government-funded research and innovation.

www.getuptospeed.org.uk

www.instagram.com/humansofstemuk

Sprinkling of science: Dr Rahul Mandal presents at Get up to Speed.

Future engineers of Fukushima

The Nuclear AMRC welcomed trainee engineers from the National Institute of Technology, Fukushima College, who will work on Japan's decommissioning programme.

The students visited the UK as part of a study programme looking at nuclear decommissioning and environmental recovery. The topic is of particular significance to the Institute and its local community following the damage caused to the Fukushima Daiichi power plant by the earthquake and tsunami of March 2011.

The visit was supported by the Nuclear Regulatory Agency in Japan, as part of the government's priority programme to train a new generation of engineers for decommissioning the power plant and cleaning up the environment.

はじめまして: visitors from Fukushima College at the Nuclear AMRC.

So why is there a crow on the cover?

This issue's cover image comes from a University of Sheffield project, The Image Speaks, which illustrates PhD research in an innovative way.

Felicity Powell is studying the Crow poems of Ted Hughes, in which the eponymous corvid is a trickster figure who bridges the rationality of the scientist and the imagination of the poet. With help from the Nuclear AMRC and Weston Park Museum (owners of the stuffed crow), photographer Andy Brown was able to capture this intriguing mix of art and science.

Diary namrc.co.uk/news/events

Some of the events that the Nuclear AMRC will be attending or supporting in the coming months – see us to find out more about how we can help your business.

Nuclear New Build 2019

11–12 June, London

The Nuclear Industry Association hosts the UK's leading new build conference and exhibition, with presentations from key players, panel discussions and more.

nuclearnewbuild2019.co.uk

Nuclear Innovation UK

2–3 July, Sheffield

The Nuclear AMRC and NNL present a major conference covering research supported by the industry-led and government-funded Nuclear Innovation Programme.

nuclearinnovation.co.uk

Engineering & Technology Solutions Exhibition

25 September, Birchwood

The UK's biggest independent nuclear suppliers' exhibition returns to Birchwood Park for networking, tech demonstrations and more.

www.nuclearexhibitions.com/BirchwoodEvent

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 **supply chain 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 Programme Director: jay.shaw@namrc.co.uk

NUCLEAR **AMRC**
ADVANCED MANUFACTURING RESEARCH CENTRE

The University Of Sheffield.

MANCHESTER 1824
The University of Manchester
Dalton Nuclear Institute

Contact us:

Nuclear AMRC
The University of Sheffield
Advanced Manufacturing Park
Brunel Way, Rotherham, S60 5WG

tel: +44 (0)114 222 9900
email: enquiries@namrc.co.uk
online: namrc.co.uk
twitter: @NuclearAMRC

Nuclear AMRC Midlands
iHub, Infinity Park, Derby, DE24 9FU

Nuclear AMRC Birkenhead facility
Cammell Laird, Campbeltown Road
Birkenhead, Merseyside, CH41 9BP

Manufacturing Technology Research Laboratory
The University of Manchester
Sackville Street, Manchester, M13 9PL

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