quarterly journal

Issue 05 amrc.co.uk

The University Of Sheffield.

Advanced Manufacturing Research Centre

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Also in this issue...

AMRC Castings Group: Europe's biggest aerospace castings facility now operational

Boeing & McLaren

announce major investments in the region

AMRC and AFRC
Catapult construction industry into world of virtual reality

Medical AMRC
Advanced mobility aid could change the lives of millions

AMRC apprentice
Experiences life as an apprentice in Brazil after award win

CATAPULT High Value Manufacturing

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Welcome to our

quarterly journal

Major inward investments give testimony to the world class research skills and capabilities on offer at the AMRC

The AMRC is renowned as a world leader for industry-focused research and development of technologies used in high-value manufacturing sectors.

In this latest issue of the AMRC Quarterly Journal, you will see how this model of collaborative research and strong links with industry continues to attract major inward investments into the region from global manufacturing companies.

Boeing is to build a new manufacturing facility, their first in Europe, alongside the AMRC to take advantage of the skills and capabilities in high-value advanced manufacturing the region has to offer.

McLaren Automotive will also build their new Composites Technology Centre alongside the AMRC, benefitting from the pool of talent being fostered at our AMRC Training Centre. The company will shortly employ their first apprentices, who will specialise in composites manufacture to help build the super cars of tomorrow.

Our Composite Centre is contributing to the idea that Sheffield's industrial past, can renew and evolve into a new manufacturing future

The rapidly expanding centre is developing the skills for Sheffield to become an epi-centre of composites research supporting innovation in the automotive industry.

As well as working with McLaren, you will read that they are undertaking a variety of projects exploring the manufacture and use of composites within the automotive sector, expanding our expertise.

We recently announced the AMRC is working with Deeside Enterprise Zone Advisory Board, Swansea University, and Coleg Cambria to develop a new Advanced Manufacturing and Research Institute in Wales.

The Institute will be developed in conjunction with SMEs and large companies thanks to a £20 million investment by the Welsh Government, and will boost the competitiveness of the Welsh supply chain.

The AMRC's continued growth includes the expansion and upgrade of our capabilities to ensure we remain a world leader when developing advanced manufacturing techniques, technologies and processes.

In previous issues of this journal, you have been following the development of the Europe's biggest aerospace casting facility being constructed by our AMRC Castings group.

The new plant is capable of producing some of the largest titanium aerospace castings in the world and is now operational. It will be used to support UK castings manufacturers to compete at a global level within markets for large-scale titanium aerospace castings.

Together with these developments of global significance, our Medical AMRC thrives in developing innovative technologies that help millions of lives on an individual level.

They are currently developing the prototype for a new kind of advanced mobility aid. The new device will improve upon the design of conventional scooters and wheelchairs, potentially changing the lives of those who live with a disability.

Prof Keith Ridgway, CBE.
Executive Chairman of the University of Sheffield Advanced Manufacturing Research Centre Group

AMRC co-founder Boeing is to open a brand new manufacturing facility in Sheffield, their first in Europe
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> “Sheffield can play a crucial role in a new Industrial Revolution”
>
> Professor Sir Keith Burnett, President and Vice-Chancellor of the University of Sheffield.

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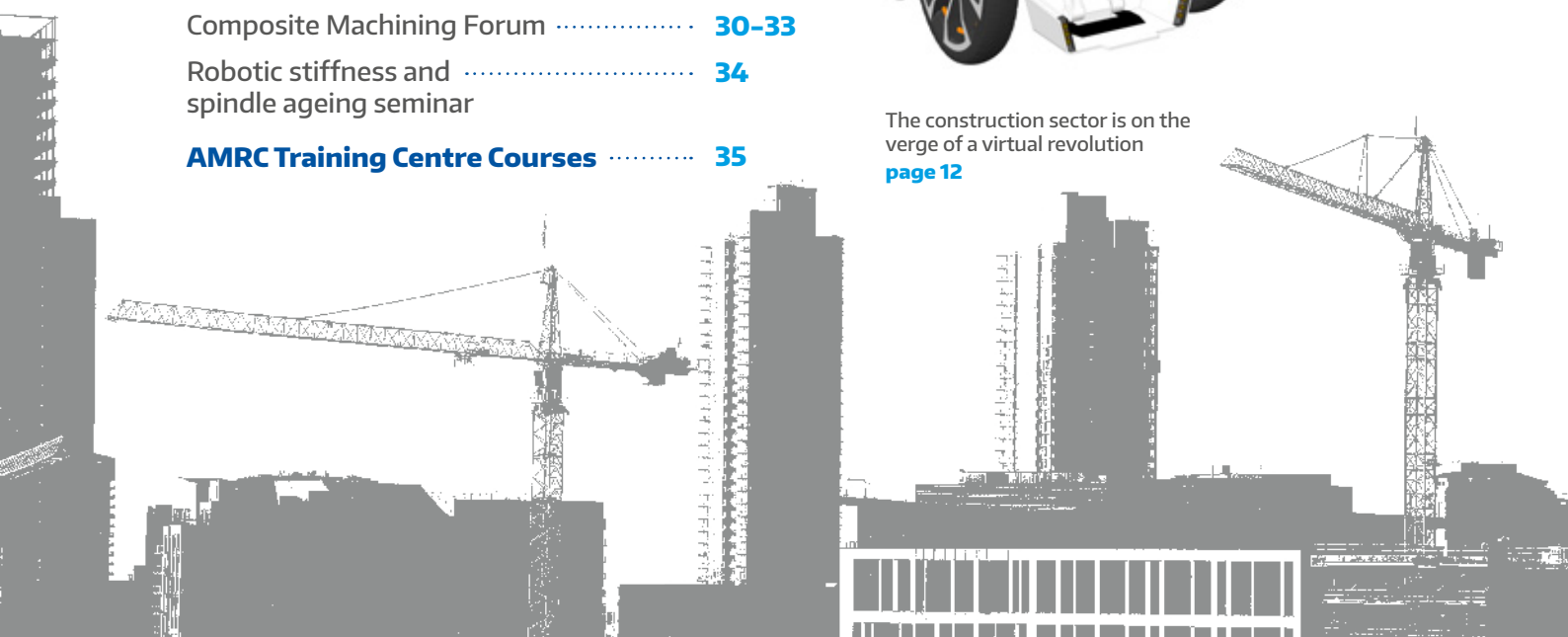


Bumotec s191 joins the AMRC

Starrag UK has enhanced the number of machines it has in-situ on the Advanced Manufacturing Park with a seven-axis Bumotec s191 linear CNC turn-mill centre being installed at the AMRC with Boeing.

This Swiss-built machine has linear drives and high-level thermal stabilisation that achieves machining accuracies of 2.5 microns in the six-sided, single set-up machining of even the most complex workpieces within the X, Y and Z axes, capacity range of 400 mm, 200 mm and 410 mm, respectively.

According to Dr David Curtis, Technical Fellow at the AMRC with Boeing: "The Bumotec s191 gives us opportunities to develop revolutionary new machining processes in any material and for any sector. We are now looking for projects where we can take small, complex components and develop optimised, cost-saving solutions that add value to UK industry."

With the main spindle complemented by a sub-spindle that can turn in both horizontal and vertical planes, the multi-functional machine offers a host of functions including turning, milling, drilling, thread generation, grinding, gear cutting and hobbing.

Tool magazine options extend to up to 90 pockets, to enhance single set-up operations on a machine with a bar capacity of 42 or 65 mm.

Rapid traverse rates of 50 m/min and a 30,000 or 40'000 revs/min spindle speed also contribute to the machine's fast cycle times.

Starrag is holding a Precision Machining Event at the AMRC on Thursday 6 July.

Attendees will be able to witness a demonstration of its prowess at presenting cost-effective and highly accurate solutions to industry in a host of materials including all metals, composites, ceramics and zirconium. Details about the free event and how to book can be found at **www.amrc.co.uk**

Geo Kingsbury wins Haas grinding machine agency

Grinding machines manufactured in Germany by Haas Schleifmaschinen GmbH are now being sold and serviced in the UK and Ireland by Gosport-based Geo Kingsbury under a sole agency agreement signed at the beginning of 2017.

The company has set up a new Grinding Technology (GT) division in Birmingham to work alongside the established Large Prismatic Machines (LPM) division in recently expanded offices on Blythe Valley Business Park.

Richard Kingsbury, managing director of Geo Kingsbury commented, "This is an exciting development that takes us into a new area of manufacturing, as our other agency lines comprise milling and turning machines.

"Haas Schleifmaschinen is a provider of very high quality grinding solutions, including simulation software and automation options, located in Baden-Württemberg close to the headquarters of our other seven principals, whose products are similarly top-end.

"We are greatly looking forward to collaborating with Haas Schleifmaschinen's senior management to develop the market over here and provide front-line service for the 62 machines that have already been installed in the UK and Ireland over the last decade."

Use of the grinders is strong in the medical sector in Ireland, while in the UK, sales of the machines have seen rapid growth in the aerospace industry, particularly in the competitive field of turbine blade tip and root grinding.

Hardware for Robin's wireless sensor unit in situ at the AMRC Factory of the Future. Right to left: Dirk Wember, Member of the Board, Haas Schleifmaschinen; Richard Kingsbury, Managing Director, Geo Kingsbury; Dean Kiefer, Business Development Manager - Grinding Technology, Geo Kingsbury; Thomas Bader, Member of the Board, Haas Schleifmaschinen.

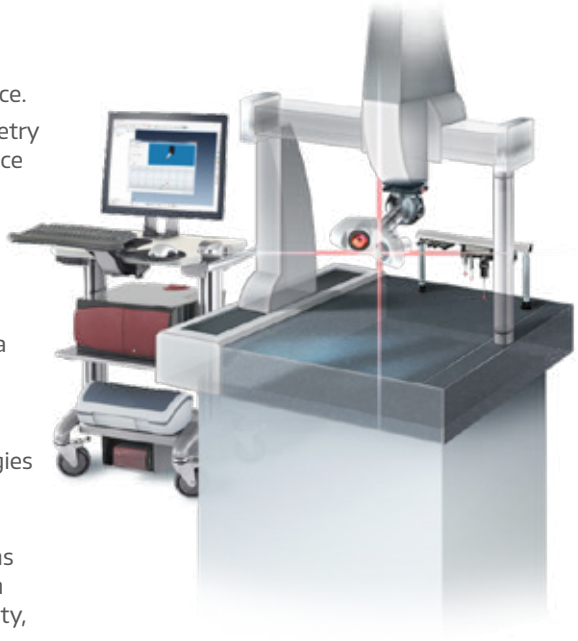
3D SCANNERS UK brings you PolyWorks 2016 – a universal 3D metrology workflow

More than ten years ago, InnovMetric embarked on an ambitious journey to deliver a universal hardware-independent 3D metrology software platform to its customers.

With PolyWorks 2016, the definition of what constitutes a universal platform takes on an entirely new meaning: a universal digitising hub that interfaces with any type of 3D metrology measurement device, and offers a universal workflow for performing all inspection tasks.

Operators are now able to:

- Define a measurement plan without being physically connected to a specific measurement device.
- Specify geometry controls on measurement objects and prepare inspection reports.
- Connect to a non-contact or a contact-based portable metrology device, or to a CNC CMM controller (from Hexagon, Mitutoyo, Nikon, Pantec, Wenzel, and I++ servers), to play the measurement sequence.
- Review measured object geometry controls and reports, or multi-piece inspection results through the built-in SPC functionality.



Thanks to the universal 3D metrology architecture of PolyWorks 2016, only minimal changes will need to be made to a PolyWorks inspection project so that it can be used with multiple hardware platforms to optimise object measurement methodologies and adapt them to different measurement principles.

As a result, PolyWorks 2016 opens a new era for universal inspection projects and device interoperability, ensuring total flexibility for customers to select the appropriate measurement devices for their needs and maximise the return on their 3D metrology investments.

Zimmer Group develop one of the world's first grippers for human-robot collaboration

In the future, more and more people will work directly with robots or be supported by them at work.

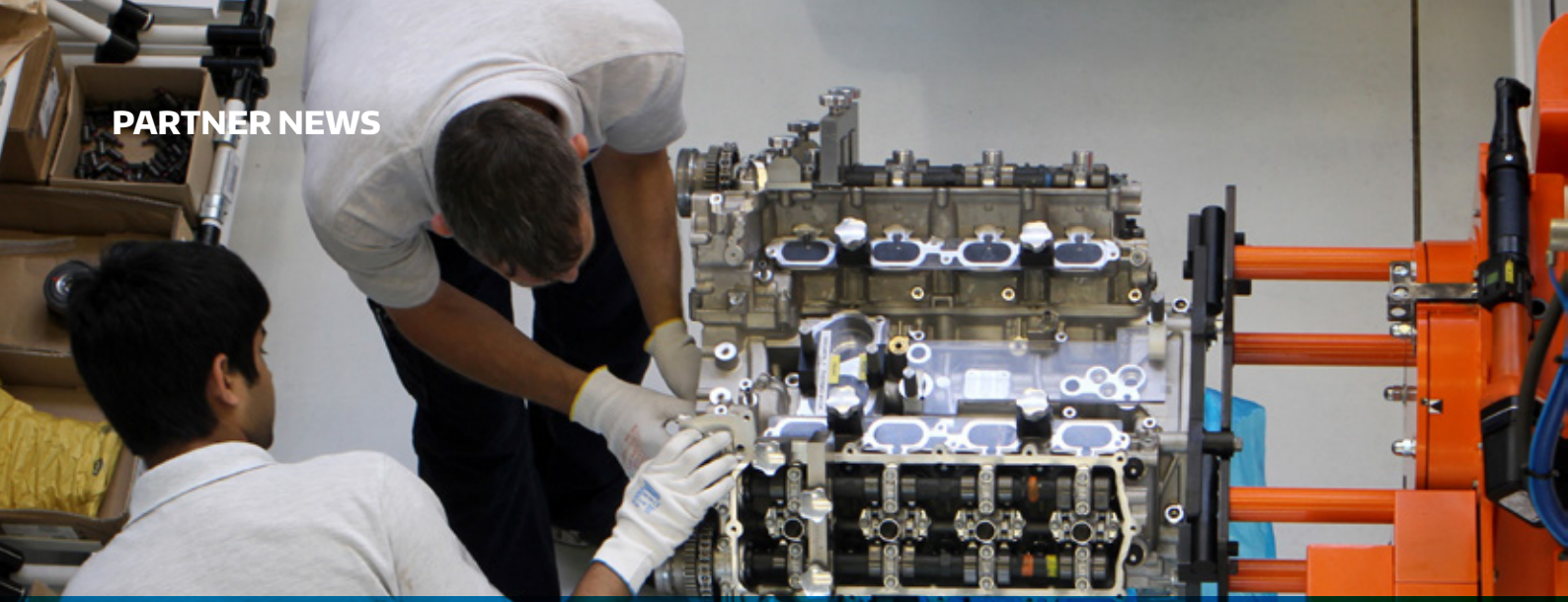
In order to ensure a high level of security in this human-robot collaboration, special robots and adapted handling components are required. Both the robots themselves and the robot tools used are subject to stringent requirements.

This has led the engineers of the Zimmer Group to develop one of the world's first mechatronic parallel gripper, the GEH6060IL, which has been especially optimised for man-robot collaboration. The gripper series GEH6060IL has been designed according to BG/DGUV recommendations and also complies with the current requirements, which are summarised in the technical specification of the ISO for the safety requirements in the human-robot-collaboration (ISO/TS15066).

This functionality in combination with an integrated safety torque-off function provides maximum security in any application. The grippers are equipped with an integrated control system and can be operated very easily thanks to an IO-Link connection.

The setting data can optionally be entered or taught. It can be centrally stored and transferred very simply to devices with the same function, which leads to a considerable time saving during implementing. Actuators and sensors can be replaced during operation, and since the setting data can be transferred quickly and error-free to the new devices, a maximum of machine availability is ensured.

The grippers offer a maximum working stroke of 2x40 mm, the gripping force can be adjusted within a wide range and ranges from 45 N to 950 N.



Ricardo collaborates with super car manufacturers to design key technical assemblies

Ricardo is a global engineering and strategic, technical and environmental consultancy business with a value chain that includes the niche manufacture and assembly of high-performance products. Recent projects have highlighted Ricardo's high profile collaborations with super car manufacturers to design key technical assemblies.

Ricardo's longstanding partnership as engine manufacturer for McLaren Automotive has seen previous collaboration on the design and development of the McLaren M838T engine and this partnership continues now with a part-funded UK Government Project (through Advance Propulsion Centre).

This project aims to design and develop technology for the next generation of high performance, low carbon powertrains and also aims to further facilitate CO_2 reductions while simultaneously increasing engine output.

Building upon its strong reputation in the design, development and manufacture of the advanced transmission and driveline systems for some of the world's highest performing supercars, Ricardo has now been selected by Aston Martin as technical and supply partner for the Aston Martin – Red Bull "Valkyrie" hypercar transmission.

The all-new, bespoke seven-speed paddle-shift transmission is being designed and will be manufactured by Ricardo in accordance with Red Bull Advanced Technologies' specification, channelling the awesome power of the Valkyrie's 6.5-litre naturally aspirated Cosworth V12 engine.

Conforming to the radical hypercar's ethos of minimal mass and maximum efficiency, and led by Red Bull Advanced Technologies' simulation work, Ricardo will deploy intelligent engineering solutions to achieve Red Bull's uncompromising goals.

OPEN MIND Expands UK Headquarters

Following exponential sales growth over the last three years, OPEN MIND Technologies UK has now expanded its operation with new staff and an expanded training room.

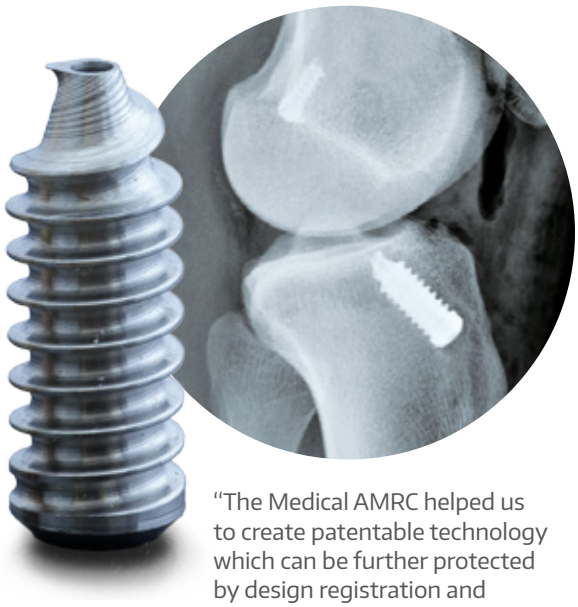
In the last two months, the CAM developer has expanded its training facility to allow over 10 customers to undertake training at any one time. This follows the re-development of the Bicester company's headquarters to expand the seminar theatre, increase its office space and refurbish the facility as well as extending the seminar theatre and adding a meeting room for customer support.

Through 2016 the leading hyperMILL CAM package exceeded all previous sales records and importantly hyperMILL noted an 150 per cent increase in enquiry levels from major UK manufacturing exhibitions.

The CAM system combines ease-of-use and an intuitive configuration with continually evolving innovative performance package enhancements such as MAXX Machining. Through 2017, the innovation is set to continue with the recent launch of Version 2017.1 and the imminent launch of hyperMILL Version 2017.2.

OPEN MIND Technologies UK Managing Director, Mr Adrian Smith said: "OPEN MIND has evolved recent versions of hyperMILL to provide an intuitive entry level system for businesses that are new to CAM software. Having an entry point for manufacturers with everything from simple 3-axis machining through to complex 5-axis requirements is enabling us to extend our reach in the marketplace. Meeting the needs of the entire manufacturing industry through a modular CAM package is why the company has extended its office space and started a program of growing the team to support our ongoing success."

Medical AMRC helps innovative orthopaedic company launch new solution for sports injuries



Researchers from the Medical AMRC have helped an innovative orthopaedic products company develop a new type of surgical screw.

The development is the brain child of world leading surgeons and Innovate Orthopaedics (IO), a new partnership developing products for the orthopaedic sports medicine market.

IO asked the Medical AMRC to evaluate two new designs it had developed for specialised orthopaedic screws.

The screws are designed for specific surgical procedures, including reconstructing the knee's anterior cruciate ligament, which can be torn during sports that involve sudden stops and changes in direction, such as football.

Reconstruction is carried out by inserting a piece of healthy tendon in place and securing it to the bone with a screw, over which the bone will grow.

Marcus Crossley, from the Medical AMRC, said: "We worked with IO to combine different aspects of their two designs and create one universal design that reduced the force needed to insert the screw while maintaining fixation."

"The design assists the surgeon by engaging more rapidly with the ligament and bone when it is inserted, reducing the fatigue experienced by the surgeon and minimising damage to the replacement ligament".

Huddersfield-based IO's founder, Alex Gutteridge, said: "Clinical tests have produced extremely positive results and we are already seeing demand rising among British and international surgeons, who see the benefit of using these innovative, new designs.

"The Medical AMRC helped us to create patentable technology which can be further protected by design registration and enabled us to quickly gain ISO 13485 medical devices quality approval and European CE marking.

"Our aim at IO is to create innovative medical devices that solve problems identified by the surgeons in order to achieve better results for their patients, without pushing up costs. The Medical AMRC has played a key part in helping us to achieve that aim with our first product."

Medical innovators aid former Marine's drive to give new freedom to millions with mobility problems

Researchers from the Medical AMRC are working with a former soldier to develop an advanced mobility aid that could change the lives of millions of disabled people.

Corporal Phil Eaglesham contracted Q Fever – also known as Helmand Fever - during active service in Afghanistan and is increasingly reliant on mobility devices as his condition deteriorates.

Phil, his wife Julie and businessman Brian Meaden, father of a mobility device user, set up Conquering Horizons to try and create a mobility device with none of the drawbacks of conventional wheelchairs and scooters.

Phil identified six key failings affecting current mobility devices, all of which are being addressed by VICTOR, the new device being developed at the Medical AMRC.

VICTOR incorporates an adjustable lifting device that can raise users to a "social height," enabling them to look people in the eye and sit at the right height to eat or work. VICTOR is also modular, so that it can be modified as a user's condition changes.

Marcus Crossley from the Medical AMRC said: "VICTOR has a completely fresh, modern appearance that is far-removed from the stigmatising, institutionalised image of existing devices."

Julie Eaglesham said: "Having this device will enable Phil and millions like him, to gain a more active, independent and normal life.

"For Phil, in his role as a father of three lively boys, the ability to travel on most surfaces or terrains and the support, comfort and control of a device that he has complete confidence in, will be revolutionary."

The Medical AMRC are currently developing two prototype devices after Victor Mobility recently surpassed their crowdfunding targets to develop the designs up to a pre-production level.

AMRC to play major role in bid to create a double economic boost for North Wales

Welsh Government plans to invest £20 million in a new Advanced Manufacturing & Research Institute have been welcomed by Colin Sirett, chief executive officer of the AMRC.

The AMRC has worked with Deeside Enterprise Zone Advisory Board, Swansea University, and Coleg Cambria to develop the new Institute in conjunction with SMEs and large companies.

The Institute will focus on research into and development of advanced manufacturing techniques and production processes for advanced manufacturing sectors including aerospace, automotive, nuclear and food. It will also address training and skills needs across industry.

Announcing the investment, during a visit to the Airbus plant at Broughton, North Wales, Welsh Economy Secretary Ken Skates said: "The Institute will deliver game-changing support to key manufacturing companies as well as multi-sector supply chain companies and the broader SMEs economy."

AMRC CEO Colin Sirett said: "The £20 million investment by the Welsh Government, combined with the £10 million from the project partners, will give an important boost to the competitiveness of the advanced manufacturing supply chain in Wales.

"The new institute's impact will go far beyond aerospace, supporting both the automotive and nuclear industries in Wales.

"It also encompasses sectors which have not traditionally been thought of as part of advanced manufacturing, which can, nevertheless, reap major benefits from the new techniques and technologies we will be developing."

The Institute will operate as a single entity, split between a proposed R&D facility at the Broughton plant of Airbus, - the anchor tenant for the new Institute - and a networking, training, business development and advice facility in close proximity to the Deeside Industrial Park.

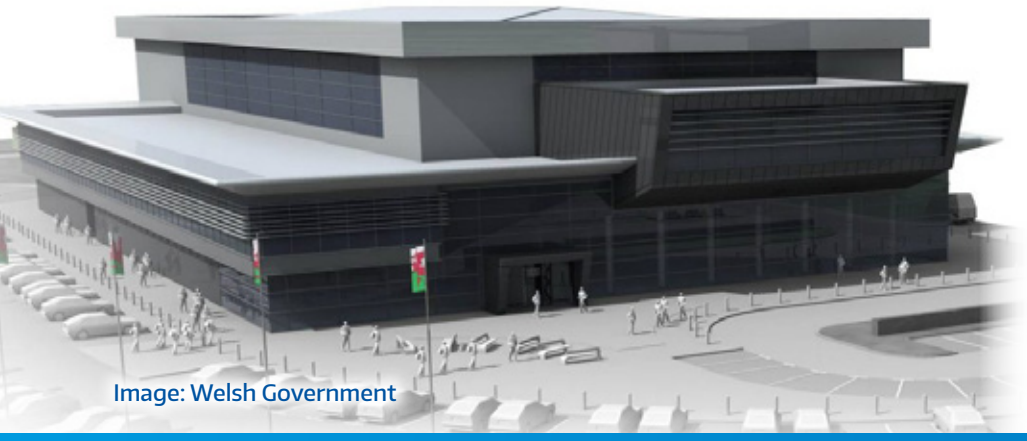


Image: Welsh Government

Former Nuclear AMRC Chief Technology Officer returns to his roots and joins the AMRC

Former Nuclear AMRC Chief Technology Officer, Stuart Dawson has joined the AMRC with Boeing as its Chief Technology Officer.

"I am passionate about aerospace technologies, so after six years in the nuclear industry I feel I have come home to my roots," said Dawson. "I am genuinely thrilled to be able to take on a new challenge and I am confident my experience in the aerospace industry will help me support a growing AMRC."

Prior to working at the Nuclear AMRC, Stuart has spent a total of 18 years working in the aerospace industry, during which time he led productivity improvement and cost reduction programmes across a variety of UK aerospace firms such as Kyocera Unimerco.

Dawson very much sees his role as further supporting the diversification of new research themes: "My key aim is to not only to support the AMRC groups in delivering results, particularly in our core competence of aerospace, but also putting a strategy into place to ensure we exploit new sector opportunities, managing the challenges of future growth."

AMRC Executive Dean, Professor Keith Ridgway, said: "I first met Stuart when he started at the University of Sheffield as an undergraduate student and have followed his career as he has moved around the cutting tool industry. Stuart has vast experience cutting the materials used in the aerospace, automotive and nuclear industries and I am delighted that he has taken such a key role with us."

EUROPE'S BIGGEST AEROSPACE CASTINGS FACILITY NOW OPERATIONAL

A castings facility capable of producing some of the biggest titanium aerospace components in the world is now operational at the AMRC.

Construction of the furnace for the AMRC Castings Group was completed last year and in the past few weeks the first tests or 'hot commissioning' as it is known, have been completed successfully.

A molten mass in excess of 1000kg is required to make a 500kg titanium casting and the furnace is one of only a handful that exist globally capable of casting near net shape aerospace components of that size.

With leading aerospace primes and manufacturing companies already lining up to collaborate on research, AMRC Castings is conducting initial paper and pilot studies to explicitly identify the risks and value streams associated with casting large-scale near-net shape components in titanium.

This research aims to refine and enhance the casting process, reassuring engineers that casting can create lower buy-to-fly ratios for large-scale aerospace components; whilst maintaining the performance expectations when compared to their forged counterparts.

Research and Development Manager for AMRC Castings, Mark D'Souza-Mathew, said: "The cost savings with near-net shape castings are huge, with efficiencies in wastage and time-savings on the machining and finishing processes. Buy-to-fly ratios are improved from 5:1 with typical forged components down to 1.5:1 via the cast route," added Mark.

Casting can produce superior material properties to both forging and machining. In particular, the new furnace built at AMRC Castings' facility allows enhanced cooling to better control the material microstructure.

AMRC Castings' new furnace is part of a major investment and R&D programme, designed to enable UK companies to break into global markets for largescale titanium aerospace engine and structural components and is backed by the UK's Aerospace Technology Initiative; its innovation agency, Innovate UK; and High Value Manufacturing Catapult. It will be ready for industrial access around Summer 2017.

AMRC Composite Centre wins funding to help keep UK at forefront of automotive innovation

The AMRC Composite Centre has won £360,000 in funding from Innovate UK, the UK's innovation agency, to investigate the way composite material is developed for use in automotive components.

The AMRC Composite Centre has formed part of a UK-wide research consortium including companies and research organisations such as Jaguar Land Rover, SGL Carbon Fibres Ltd, the University of Nottingham and Nifco UK Ltd; to focus on creating strong lightweight vehicle and powertrain structures to help vehicles deliver lower emissions.

AMRC Composite Centre Partnership Lead, Hannah Tew, said: "Our role within the research project is to look at how preformed blanks of carbon fibre reinforced plastic (CFRP) composite material can be made cheaper, faster and stronger, using less material to produce lightweight composite automotive assemblies."

Composites Technical Lead, Dr Hassan El-Dessouky, said the AMRC Composite Centre will investigate the use of creating the CFRP material using 3D weaving of commingled fibres and co-weaving of carbon and thermoplastic fibres:

"The 3D weaving will provide different material properties for the preformed blanks than traditional 2D technology, improving performance and making it quicker to produce. It is hoped we prove that less material will be needed making 3D woven CFRP more cost-effective."

Research will also be carried out to see if the way the CFRP fibres are orientated during weaving affects the production and quality of the composite material, allowing the team to improve component geometry and 'lightweight' the composite material.

Hannah Tew, said: "Using composites in these kinds of component assemblies is not common at the moment, but the hope is the Innovate UK funding will assist UK automotive manufacturers to drive the supply chain for composite material technologies, keeping us at the forefront of innovation."

AMRC becomes part of £60 million bid to explore and improve new manufacturing techniques

The AMRC has been named a partner in three of the UK's new Future Manufacturing Hubs.

Universities and Science Minister Jo Johnson unveiled the plan to create six new £10 million research hubs that will explore and improve new manufacturing techniques.

The hubs will draw together expertise from 17 universities and multiple industrial and academic partners, funded by the Engineering and Physical Sciences Research Council (EPSRC).

EPSRC chief executive, Professor Philip Nelson, said: "Some of these new Hubs will build on the solid foundations of earlier Centres for Innovative Manufacturing while some, like the Hubs at the University of Sheffield are completely new ventures that have strong links with industry and organisations such as the Advance Manufacturing Research Centre."

The AMRC is a partner in Future Manufacturing Hubs focusing on advanced metrology, composites and manufacture using advanced powders and processes.

The Advanced Metrology Future Manufacturing Hub will be led by the University of Huddersfield.

The Hub will develop new measuring technologies to be incorporated into machine tools and systems for extracting and interpreting data, which could be used to analyse and improve machine performance and product quality.

The AMRC and the University of Sheffield's Department of Automatic Control and Systems will test the technologies at Factory 2050, the AMRC's reconfigurable, digital factory for collaborative research.

The Future Composites Manufacturing Hub will be led by the University of Nottingham and has been set up to drive the development of automated manufacturing technologies that deliver components and structures for demanding applications, particularly in the aerospace, transportation, construction and energy sectors.

The Future Manufacturing Hub in Manufacture using Advanced Powders and Processes is being led by the University of Sheffield and has been set up to deliver on the promise of powder-based manufacturing processes to provide low energy, low cost, and low waste high value manufacturing routes and products to secure UK manufacturing productivity and growth.

Composite robot offers flexible, low cost alternative to purpose built machining solutions

Machining, composite and integrated manufacturing specialists at the AMRC have joined forces to build what is believed to be the world's first reconfigurable carbon composite robotic machine tool.

The carbon composite robot project is part of the AMRC's contribution to the Factory of the Aircraft Future project, backed by the Aerospace Technology Institute, which was established by the government and aerospace industry to sustain and grow an internationally competitive UK aerospace sector.

The project brings together aerospace giant Airbus and system manufacturer Exechon, which specialises in Parallel Kinematic Robots, to develop a new lightweight and modular version manufactured and tested by AMRC.

Most robots in industry today use serial linkage technology, where each additional axis is mounted on the previous one, with an 'end effector', which holds the tools the robot uses – on the final axis.

Parallel Kinematic Robots have the end effector mounted between two or more independently moveable arms, allowing movements in the in X, Y and Z directions to be made using three or more parallel axes.

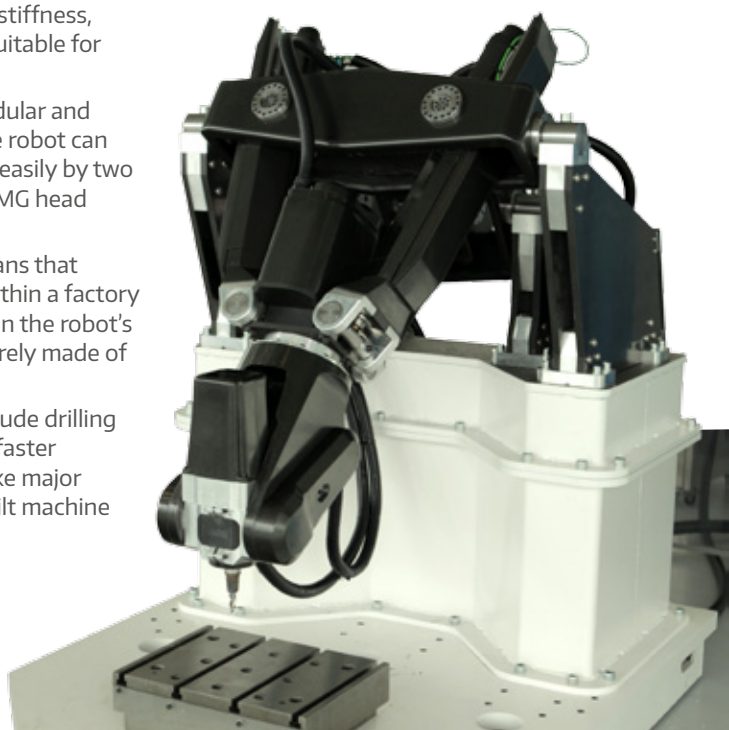
Proponents say Parallel Kinematic Robots can move as flexibly in the same volume as robots with a single arm but with greater accuracy and stiffness, which makes them more suitable for machining operations.

"Making the structure modular and from composite means the robot can be dismantled and moved easily by two people," says the AMRC's IMG head Ben Morgan.

"Using composite also means that changes in temperature within a factory will have less of an effect on the robot's accuracy than if it was entirely made of metal.

"Potential applications include drilling and milling holes in wings faster and without having to make major investment in purpose-built machine tools, which cannot easily be moved."

The AMRC's Composite Centre made the bulk of the parts for the robot, its Machining Group and apprentices from its Training Centre made all the metal components and the Integrated Manufacturing Group has assembled and is running trials of the finished robot.



Supporting developments in lightweighting helps UK companies take advantage of opportunities in global aerospace markets

The AMRC's Advanced Structural Testing Centre (ASTC) is working in collaboration with UK company TISICS exploring the development of materials for demanding environments.

TISICS specialise in the development and manufacture of high strength, lightweight, titanium metal matrix composites. Reinforced with silicon carbide monofilaments, the material is of great benefit where high strength and low weight are critical to performance.

As part of a programme of work co-funded by Innovate UK, the ASTC will be working with TISICS to complete fatigue testing and certification on titanium composite actuator rods.

Developed for use in commercial aircraft assemblies such as landing gear, wings and engines, the rods are reinforced with silicon carbide; a metal matrix composite designed with exceptional compression strength.

TISICS are also developing actuators rods for highly specialised aerospace technology such as satellites where 'lightweighting' is critical to the design of components.

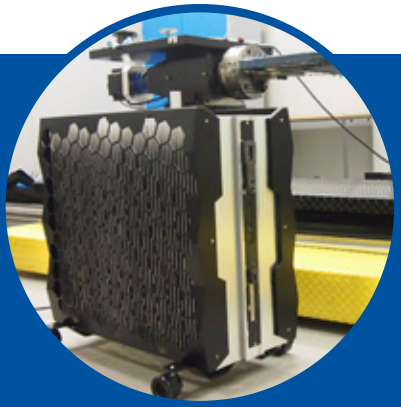
Head of the ASTC, Phil Spiers, said: "Materials used in high-value applications such as this, are required to operate in demanding environments. The ability to develop materials tailored to these situations gives UK businesses a competitive edge in a global market."

"The project will open up big opportunities in the aerospace sector as there can be as many as a few hundred actuator rods in every aircraft. Weight savings can many provide opportunities to create value and improve performance."

Managing Director of TISICS, Stephen Kyle-Henney said: "TISICS metal composite technology has the potential to save 35 to 70 per cent weight on many aircraft and space system components. This work demonstrates the advances in the material and manufacturing performance over the past four years.

"The data produced by the project will enable us to verify performance and raise investment to mature the technology to production, generating UK jobs and international product sales in these growing high value markets."

New AMRC partnership with Iceotope to foster innovations in IT for manufacturing sector



Iceotope is making waves in the manufacturing sector by demonstrating their liquid cooling system for high-performance computing (HPC) in harsh and rugged environments at the AMRC.

Using their patented liquid cooling technology, Iceotope have developed a high-performance workstation suitable for office environments which replaces air cooling with passive liquid cooling and a data centre facility consisting of sealed server blades immersed in safe, non-flammable coolant, to capture and reuse waste heat for greater efficiency.

AMRC IT Systems Manager, Chris Hodgson, said: "Creating HPC facilities within a manufacturing environment can be challenging due to the variety of settings and uses required.

"Servers and workstations need to be protected against hazards such as dust and debris created by manufacturing processes. Increasingly flexibility of location and efficient heat management are also required for office-based computing centres. Placing the computing power at the edge of the network also reduces bandwidth and interconnectivity requirements."

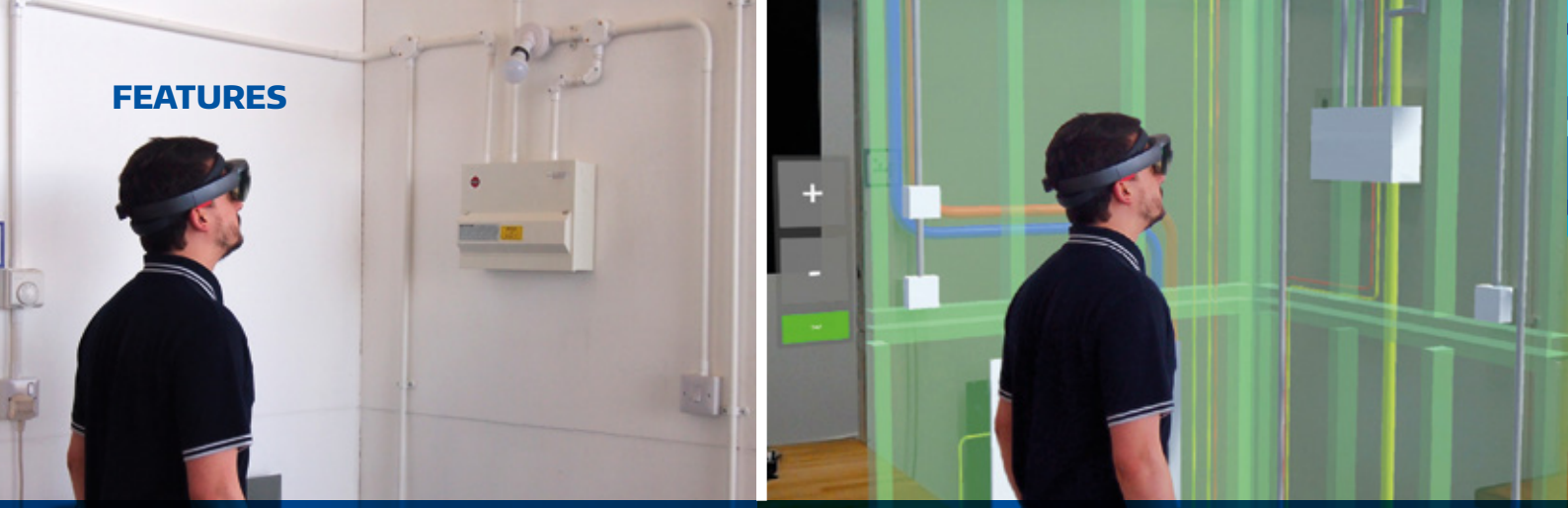
Workstations will be trialled in the AMRC's Design, Prototyping and Testing Centre, on the workshop floor of the Composite Centre and a data centre facility will be trialled in the AMRC's newest development Factory 2050, to assist in the processing of 'big data' for a large volume metrology project.

Sam Hyde, a project engineer with the AMRC's Design and Prototyping Group said: "The power available with the Iceotope system is ideal for computationally intensive work, such as computational fluid dynamics, finite element analysis and 3D rendering"

"It is useful that the machine is totally silent in operation, which allows us to keep the machine in the office and not need a dedicated room for the equipment."

Peter Hopton, founder and technology director of Iceotope, said: "We're very excited about our strategic partnership with the AMRC.

"We protect critical data from harsh environments – the perfect solution for a factory floor. The AMRC now have high performance 'edge of network' machines which, thanks to liquid cooling technology, offer fast and flexible deployment for their manufacturing workloads.



Left: How the physical environment looks in reality and... Right: the 3D rendering that the operator of the Microsoft HoloLens sees.

AFRC and AMRC aim to catapult construction industry forward

The construction sector is on the verge of a virtual revolution,

thanks to the work of a consortium of organisations, including the University of Strathclyde's Advanced Forming Research Centre (AFRC) and the Advanced Manufacturing Research Centre with Boeing (AMRC).

Working with Glasgow-based design visualisation company, Soluis Group, and modular building designer and manufacturer, Carbon Dynamic, the cohort of organisations has successfully built a demonstrator for the use of augmented and virtual reality (AR and VR) in the construction industry.

With backing from the High Value Manufacturing Catapult (HVMC) visualisation forum, the organisations developed a platform demonstrator that, when installed on an AR headset, can visualise the interior of a building part – specifically, in this case, a wall. The technology was recently showcased at the Applied Visualisation Community event at the British Motor Museum in Gaydon, Warwickshire, where it took the form of a 2.2-metre plasterboard wall which, when viewed with a Microsoft HoloLens, showed a 3D rendering of the plumbing and wiring behind the façade.

In addition, when using a Microsoft HoloLens which incorporates a number of environment understanding cameras, the system can be used to examine different wall parts to ensure there are no gaps in insulation, before they are sent to a construction site. This could significantly cut costs, save time, and enhance quality assurance on modular construction projects.

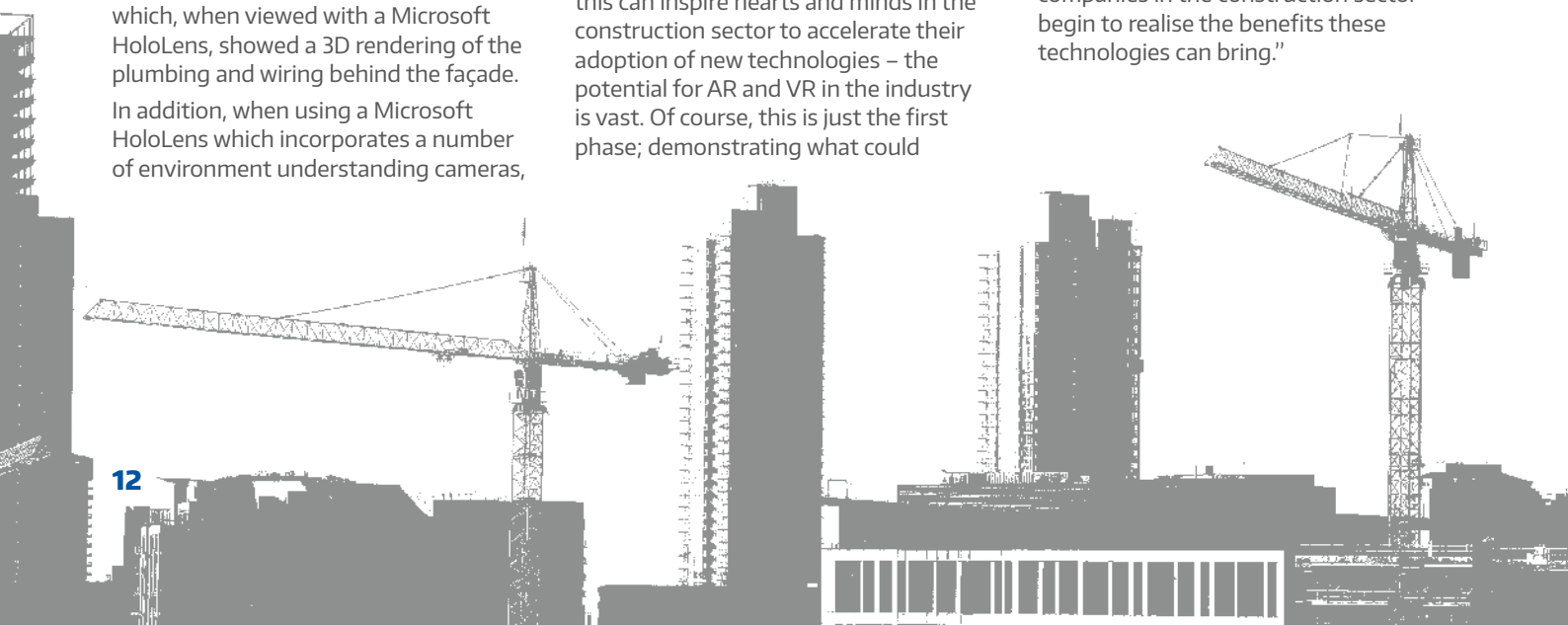
The initiative comes as the UK Government's building information modelling (BIM) mandate continues to roll out across the country. AR and VR technologies are seen as critical to the construction industry's adoption of BIM.

The team behind the demonstrator said it was the first step forward in bringing a commercially available platform technology to market – but there is still work to be done.

David Grant, partnership development leader at the AFRC, said: "Projects like this can inspire hearts and minds in the construction sector to accelerate their adoption of new technologies – the potential for AR and VR in the industry is vast. Of course, this is just the first phase; demonstrating what could be achieved if the right platform was developed as a standard for the industry – the tools still need to be created.

"Working with the AMRC has been absolutely crucial to getting to this point – the centre has been working in AR and VR technologies for a long time. We've been able to learn from its experience, which has been absolutely invaluable. It shows what can be done when HVMC centres work together."

Chris Freeman, technical lead for augmented reality, at the AMRC with Boeing, added: "The AFRC was integral in laying the groundwork for the demonstrator, with thorough research and identifying the business drivers for introducing AR and VR capabilities. We're hoping to do more in this area with our industrial partners, as more companies in the construction sector begin to realise the benefits these technologies can bring."



AMRC Apprentice of the Year experiences life as an apprentice in Brazil

Sam Brookfield, 18, is a manufacturing apprentice with long-established Sheffield manufacturers of industrial fasteners, Cooper & Turner.

He won a trip to Brazil, courtesy of WEG to see its main manufacturing sites and visit the Brazilian coastline after winning Apprentice of the Year at the 2016 AMRC Training Centre, Apprentice of the Year Awards.

WEG is the largest Latin American electric motor manufacturer with operations in 100 countries.

The trip was in November and Sam visited the company's main factory site at Jaraguá do Sul in Santa Catarina, the Transformer Factory in Blumenau and had two days at the beach resort Balneario Camboriu.

He came back to the steel city with plenty of knowledge of how Brazilian manufacturing compares to the UK and was able to discover what life is like for an engineering apprentice in Brazil.

"My apprenticeship course is a CNC programming course and it's part of my role at Cooper & Turner, so it was good to see how WEG do their CNC programming on their CAM systems," said Sam.

"I was shown how they make different components, for example the drive shafts and how they CNC different products. It was interesting to see the different styles of systems used."

Sam was particularly impressed in WEG's health and safety systems. "Each manufacturing section has its own safety rating, instead of a division-wide one," he said. "And for each year there were no accidents reported the section would hang a new banner, for the fifth year the managing director would come to the shop floor and meet the operators.

"When I toured there was one section that hadn't had a reported accident in 22 years! They have a great understanding of safety policies and a different culture around the awareness of safety and are rewarded for it."

Sam also toured the Transformer Factory in Blumenau which is the main transformer manufacturing site for the whole of Brazil and spent the day with the WEG apprentices at their apprenticeship school.

"It's a small scale version of their factory where the apprentices learn the exact skills and techniques they will use when on the full-scale factory floor," said Sam.

"They stay at the apprenticeship school for six hours a day, and then have a break and return for another six hours of academic and theory study."

Sam said he had found the tours fascinating especially seeing the large scale that WEG works on.

"It's interesting to see how methods of management and inspection techniques of the manufacturing processes were almost identical," he said.

"I was expecting them to be similar, but it shows that tried and tested methods are used from small-scale to mass-production scale facilities."

Sam finished off his trip in Balneario Camboriu where he took a cable car to the top of a 260m mountain before zip lining back down.

"It was a lovely place to visit, it's perceived to be a really hardworking affluent district. It's definitely one of those places you just want to visit again, the people are so friendly."

Boeing to open new manufacturing facility in Sheffield City Region, alongside the AMRC

AMRC co-founder Boeing is to open a brand new manufacturing facility in Sheffield, their first in Europe.

The facility, to be named Boeing Sheffield, will enable Boeing to bring the manufacture of key high-tech actuation components and systems used in Boeing's Next-Generation 737, 737 MAX and 777 aircraft in-house, enhancing production efficiency and reducing costs.

Rendering only: design subject to change pending planning approval. Image: Boeing.

> “It gives testimony to the world class research skills and capabilities on offer at the University of Sheffield and the AMRC, supporting the major investments coming into the region.” Professor Keith Ridgway

Professor Keith Ridgway, Executive Dean of the AMRC said: “It has always been our ambition that one day Boeing would open a manufacturing facility in Sheffield. This announcement is the culmination of a successful relationship that has developed since the AMRC with Boeing was founded 16 years ago.”

At the turn of the century, Prof. Ridgway and local businessman Adrian Allen began to work with the aerospace giant to apply Sheffield’s traditional expertise to new materials, focusing on machining research. The result was the establishment of the AMRC as a centre for collaborative research.

Adrian Allen, Executive Director of the AMRC, said: “Keith and I set out to create a radical, unique collaborative research environment; one that would quickly grow and become a catalyst for attracting a pool of skilled talent, technology and inward investment. This would be the critical success factor in achieving the vision we had, to become the world’s foremost innovation district.”

In the past 16 years, the AMRC has grown to include over 90 industrial partners from sectors such as aerospace, medical, automotive and construction and has become a model world-wide in how to conduct collaborative research to develop new manufacturing techniques and technologies. The AMRC and its partners are now a central offer for the Sheffield City Region’s Advanced Manufacturing Innovation District.

As part of the plans for its new facility, Boeing will initiate a major research and development programme with the AMRC to develop new manufacturing techniques that can be applied in the Boeing Sheffield facility.

Sir Michael Arthur, President of Boeing Europe and Managing Director of Boeing UK and Ireland, said: “The UK provides Boeing with the talent and infrastructure we need to grow and maintain a high level of productivity and quality to meet our significant order book.

“We are proud to expand our relationship with the UK still further with Boeing Sheffield. Our decision to start manufacturing high-value components in the UK is a step-change in our engagement and a further example of Boeing’s commitment to grow here, supporting the UK’s long-term prosperity.”

Boeing Sheffield is expected to begin hiring new employees in 2018 - capitalising on the skilled workforce in Sheffield as well as the AMRC‘s existing capabilities.

“This announcement reinforces that region is a leading location for high-value advanced manufacturing,” said Prof. Ridgway.

“It gives testimony to the world class research skills and capabilities on offer at the University of Sheffield and the AMRC, supporting the major investments coming into the region. Investments that will provide opportunities for the UK supply chain. We look forward to supporting Boeing and continuing to ensure that UK manufacturers remain competitive, through access to our expertise here at the AMRC.”

Professor Sir Keith Burnett, President and Vice-Chancellor of the University of Sheffield, said: “This is hugely important, not only for our region and the North of England, but also the UK’s global industrial ambitions in high-productivity, high-value manufacturing. Areas such as Sheffield can play a crucial role in a new Industrial Revolution for the UK - one centred on science and innovation, but working hand-in-hand with industry. I am deeply proud that leading global companies recognise that Made in Sheffield still remains a hallmark of quality.”

World Copyright: PatrickGosling / Beadyeye

McLaren Automotive **partnership with AMRC will see super car chassis built in Sheffield**

Luxury, high-performance sports car manufacturer McLaren Automotive has launched a pioneering partnership with the AMRC.

The AMRC will use its expertise to develop advanced manufacturing processes that will allow McLaren Automotive to produce the advanced carbon fibre chassis for its future sports cars.

The new processes will be proven at the AMRC, in readiness to transfer them to a full-scale manufacturing environment inside McLaren Automotive's new Composites Technology Centre, which will be built in Sheffield.

The centre will host more than 200 hi-tech automotive jobs and will be in the vicinity of the AMRC's hi-tech Factory 2050 development; where a new Lightweighting Centre will also be built to house the AMRC's existing Composite Centre.

AMRC Executive Dean, Professor Keith Ridgway CBE, said: "This is a tremendous piece of news for the Sheffield City Region and a boost for its future as the UK's centre for advanced manufacturing.

"In many respects it represents a new model that repositions manufacturing in Sheffield, taking it on from coal and steel to high performance components for the automotive, as well as the aerospace, sector.

"We will be working with McLaren Automotive's on the construction of the carbon fibre chassis and further research, and we are talking with the

supply chain. It is our ambition that supply chain companies will start to build factories here to supply the chassis plant."

Prof. Ridgway praised the University of Sheffield, Sheffield City Region Local Enterprise Partnership, Sheffield City Council and its inward investment arm, Creative Sheffield, for their part in helping to clinch the deal.

"The LEP, Creative Sheffield and the Council were very supportive. It was probably the best coordinated activity we have seen and enabled us to put together a strong case for McLaren to come here," Prof. Ridgway added.

"For the AMRC this is confirmation of the growing expertise of our composites research team and their ability to meet the needs of industrial partners."

The announcement builds on the continued international success of the AMRC as an epicentre of regional and national economic impact and a source of apprenticeship opportunities for young people in industry; as the AMRC Training Centre will also start training McLaren apprentices who will work in the new facility.

Speaking at the launch, Mike Flewitt, Chief Executive Officer at McLaren Automotive, said: "Why Sheffield? Because of the local expertise and experience of working with new materials and advanced composites, plus the development facilities offered by the University of Sheffield and their AMRC facility. With other high-tech organisations, such a Boeing, Airbus, GKN and Rolls Royce plc alongside us at the AMRC, we are in very good company."

The new McLaren Automotive facility is due to start construction in early 2017 with the first pre-production carbon fibre chassis, built using trial manufacturing processes in the AMRC, expected to be delivered to the McLaren Technology Centre in the second half of 2017. Full production at the facility will begin by 2020.

(l-r) Councillor Chris Read, Leader of Rotherham Metropolitan Borough Council, Councillor Leigh Bramall, Deputy Leader of Sheffield City Council and Cabinet Member for Business and Economy, Mike Flewitt, Chief Executive Officer of McLaren, Sir Nigel Knowles, Chair of the Sheffield City Region LEP and President and Vice-Chancellor of the University of Sheffield, Professor Sir Keith Burnett with McLaren supercars at AMRC Factory 2050.

AMRC Research Groups welcomed partners to this year's conference to learn about their progress, achievements and future plans.

TECH FELLOWS CONFERENCE 2016

AMRC aims to double turnover in coming five years despite the uncertainty of the past 12 months

Colin Sirett, AMRC chief executive officer

Huge opportunities are opening up for the AMRC as it continues to expand, despite significant challenges at home and abroad, Chief Executive Officer Colin Sirett told representatives of partner companies attending the organisation's annual Tech Fellows event.

The organisation was aiming to double its turnover in the next five years as it takes its model and services further afield from its base in the Sheffield City Region.

"We have had sustained growth over 15 years and every time we think we have reached a steady state, we start growing again. There is a huge opportunity for the AMRC, but there is also risk and massive challenge," said Sirett.

The last 12 months had seen the global economy stutter, the UK vote to leave the EU and a six month hiatus affecting aerospace and automotive research funding due to the UK Government's comprehensive spending review.

The ensuing uncertainty had led some centres in the UK's research network to become very cautious, while others decided the UK had to continue investing in research and they had better get on and do it.

"We are very much promoting the latter view. We are open for business, we are pursuing business and we are looking to grow," said Sirett, adding: "That is a pretty powerful position to be in.

Key streams of funding for the areas the AMRC was working in had had their budgets relatively well protected and the AMRC was fortunate to be based in a region that had benefitted financially from Government devolution.

The financial benefits and the AMRC's capabilities had laid the foundations for potential significant aerospace and automotive investments in the region.

At the same time, demand was increasing for the AMRC's outreach work, providing in country support in collaboration with local partners, with developments coming to fruition at home – in the North West and Wales – and abroad, in Korea and the US.

"This is not just the AMRC peddling its wares to whoever wants to pay us, "said Sirett. "There is sound national rationale and benefit."

"Global growth rates in the aerospace and automotive sectors are absolutely phenomenal, which means there is more work to be done and we are looking for more of that work to be done in the UK.

"We can operate offshore and remain true to the UK taxpayer by creating solutions that result in more work coming back to the UK all the time."

> **"Global growth rates in the aerospace and automotive sectors are absolutely phenomenal"**

Exciting times for the AMRC as it launches new plans for growth and increased membership benefits

Prof. Sam Turner, HVMC chief technical officer

High Value Manufacturing Catapult (HVMC) Chief Technical Officer, Professor Sam Turner, who was CTO for the AMRC at the time of the conference, is predicting "exciting times" for the AMRC as its growth accelerates and it increases access so that partners can gain even more from membership.

Speaking at the AMRC's annual Tech Fellows Conference, Prof. Turner outlined opportunities for partners and the AMRC to benefit from a range of initiatives designed to support manufacturing and enable UK industry to become more competitive.

He also explained how the AMRC was seeking to demonstrate and exploit its cross group capabilities in technologies such as digital, near net, gear and transmission manufacturing, and sectors such as transport, infrastructure and healthcare.

"The AMRC is the place where Digital meets Manufacturing," Prof. Turner told the conference.

"We are making a huge investment in digital infrastructure and demonstrators, including investment in digital technology. We are creating a digital thread across the AMRC campus, including the development of digital twins, a digital machine shop, digital Lightweighting Centre and a digital foundry.

The AMRC will be helping companies to develop their capabilities by taking an agnostic approach to new technologies, assessing their capabilities, finding the right solution and de-risking it.

Activities could span everything from simulating factories and investigating the technologies they might use to assisting with their physical development.

Digital manufacturing was one of two areas where there were opportunities for developing a national manufacturing strategy. The other was near net additive manufacturing.

"There is a real need to create a showcase that will demonstrate the benefits of these two technologies and we believe we can deliver a real step change by using Factory 2050 as that showcase," said Prof. Turner.

Record order books fuelling growth of AMRC Composite Centre

Richard Scaife, manager of the AMRC Composite Centre

Record order books, rising turnover and the prospect of securing new members are helping to fuel the growth of the AMRC Composite Centre.

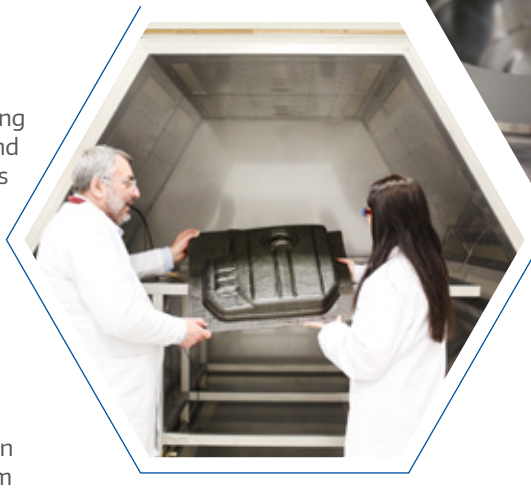
Centre manager Richard Scaife told the AMRC Tech Fellows Conference turnover was expected to rise to more than £5.2 million this year, from £4.4 million and the Centre's £6.6 million order book was the largest ever.

Staff numbers had grown by more than a third to 46 and were likely to rise to around 55 during the coming year as the Centre prepared to move to new facilities on the new Advanced Manufacturing Campus, adjoining Factory 2050 and a new press for hot processing composites.

The Centre was continuing to pursue its four core research themes – automated production, advanced curing technologies, composite machining and novel materials and processes and was developing a new theme, focused on its work on dry fibre processing, as a result of increasing demand in that area.

Looking to the future, the Composite Centre was aiming to further develop microwave, automatic fibre and tape placement and thermoplastic and thermosetting technologies in addition to planning further investment in loom and braiding technology.

"Preforming seems to be a growing field for us, particularly in the automotive field, meanwhile our composite machining team is growing the breadth of its work and seeking to increase involvement further with partners," said Richard Scaife.



Benchmarking machining processes and tooling to make manufacturing composites cheaper, faster and safer

Dr Kerrigan, technical lead researcher for machining, AMRC Composite Centre

Dr Kevin Kerrigan told delegates the AMRC that increasing use of composites in the aerospace and automotive sectors was leading to a rapid growth in interest in machining.

Image: Rolls-Royce.

The Centre was seeking to make machining composites cheaper, faster and safer so that it became more attractive to machine composites than to use alternative technologies.

As part of that process, the Centre was looking at working with the supply chain to benchmark not just cutting tools, but fluids and tool holders, and using modelling and finite element analysis to predict the way a tool will behave.

The Centre was investigating the machinability of composites and quality of cut, the comparative benefits of wet and dry machining, part accuracy, fixturing, advanced processing using ultrasonic assisted and non-conventional techniques and design for manufacturing.

Further research into the efficacy of robotics in composite machining applications is also under investigation, meanwhile, health and safety issues related to machining composites are becoming deserving of their own area of research, which did not solely cover the risk of inhalation, said Dr Kerrigan.

Machining group plans for growth with more fundamental research and a broader sector focus

Tom McLeay, head of core research for the AMRC Machining Group

Further expansion and a focus on more fundamental research alongside development of a truly 'digital machine shop' are among the developments planned for the AMRC's Machining Group in the coming year.

Group Head of Core Research, Tom McLeay, told Tech Fellows delegates his team, which focuses on fundamental research topics and machining science, now had 22 staff, half of whom had PhDs, and was likely to increase to 30 by the end of 2017, not including 15 students in the AMRC-based Industrial Doctorate Centre.

The Machining group as a whole has similar growth forecasts, expecting to grow from the current 85 staff to more than 100 in six months.

The group was now planning to increase its presence in the automotive sector and develop a stronger foothold in lower Technology Readiness Level research into machinability, tool wear and part inspection.

Delegates to Tech Fellows also heard how the group was also planning to rebuild a legacy machine tool, retrofitting sensors and developing software controls, while also furthering its interest in temperature measurement in milling, leading towards the creation of a system that could be retrofitted to machines. This model looks to provide smaller enterprises with access to the latest technology.

The group also plans to study changes in temperature at the interface between cutting tools and component material was leading to the development of new techniques to compensate for the slow response of temperature sensors.

Machining Group researchers are also studying:

- The potential for cryogenic cooling to improve tool life and surface finish and reduce health and safety issues.
- The effects of thermal and mechanical loads on surface integrity.
- How Squeeze Film Damping, using a machine tool's own coolant, could reduce vibration, without the risk of causing deformation.

Grinding team expands its capabilities on back of growing research programme

Dr David Curtis, AMRC technical fellow

The AMRC's grinding and surface finishing team has grown to employ 10 staff, using eight machine tool platforms to undertake £3 million-worth of project work, technical fellow Dr David Curtis told Tech Fellows delegates.

Developing focus areas included gear, surface profile and cylindrical grinding, and research into novel materials and processes, said Dr Curtis.

The team was developing a standard test for grinding wheels and had created a proven process that was being used to study grinding wheel breakdown and wear for base line abrasives before moving on to benchmarking a range of products.

Team members were studying the grindability of different materials and standard features such as those found on aerospace blades and vanes and developing ways of detecting grinding burn and the level of burn during processing.

Research was also continuing into gear grinding using more flexible platforms, including mill turn machines and combining the turning, milling and grinding process.

New strategy cuts time and cost of machining thin walled components

Pete Woodthorpe, project manager for the AMRC Machining Group

40% reduction

A new machining strategy, developed by the AMRC in collaboration with cutting tool manufacturer Sandvik and fixturing specialist Craftsman Tools is set to help an aero engine component supplier significantly reduce the time and cost involved in machining thin walled rings.

AMRC Machining Group Project Manager Pete Woodthorpe told the Tech Fellows conference the AMRC's scientific approach to understanding distortion and residual stress in the rings, which had a 2mm wall thickness, had been the foundation for the development of a highly aggressive new manufacturing method.

The new process had reduced the number of operations involved by 40 per cent and could cut the time taken from 16.5 to 9.5 hours.

It had also resulted in the company's engineering team gaining new skills, while ensuring the company was competitive and secured new orders.

"This is a good example of cross group working assisting a UK company and benefitting the aerospace sector and UK industries," said Woodthorpe.

Investigating the potential of hybrid manufacturing technologies

Ian Ness, AMRC manufacturing engineer

The AMRC is building up its expertise in the new field of hybrid manufacturing after becoming one of the few centres in the world to acquire a £1.2 million DMG Mori Lasertec 65 3D additive and subtractive machining centre.

Fewer than 10 of the machines are currently being used in production across the world and could be used to repair as well as manufacture components.

AMRC Manufacturing Engineer Ian Ness told Tech Fellows delegates the machine could make components from nickel-based alloy, stainless steel, tungsten carbide, bronze and brass powders and had the capability to deposit multiple layers of different materials.

The AMRC is using the machine to investigate the impact of different powder characteristics, feed rates, mass and gas flow affected the properties of the finished component.

The machine is also being used to help the AMRC develop its hybrid manufacturing CAD and CAM capabilities, starting with producing basic, then intermediate shapes and finally advanced conical cylinders with bosses, splines and aerofoils.

Ian Ness said future research would examine the effect powder grain size, material composition and oven treatments had on components, powder loss during deposition and the impact of wet surface deposition – attempting to add layers when the component was covered with a layer of coolant oil.

Image: DMG Mori

L: Dennis Fretwell, R: Dr Robert Carroll, AMRC Machining Group technical fellows

New approach to creating tool paths offers prospects of major time savings

The time taken to create tool paths for machining bosses on aero engine casings could be cut from hours to minutes thanks to a new approach that could have major implications for other machining applications.

AMRC Machining Group Technical Fellow Dennis Fretwell says creating a sketch for the tool path currently involves a modeller and experienced NC programmer spending a significant amount of time using extensive editing capabilities.

"It's time consuming – producing one tool path for a small portion of the casing takes hours and each path is specific to the tool diameter," says Fretwell.

"It can take two and a half hours to create a tool path that takes minutes to run. If you change the tool you have to change the sketch and the same is true if you add or move a boss."

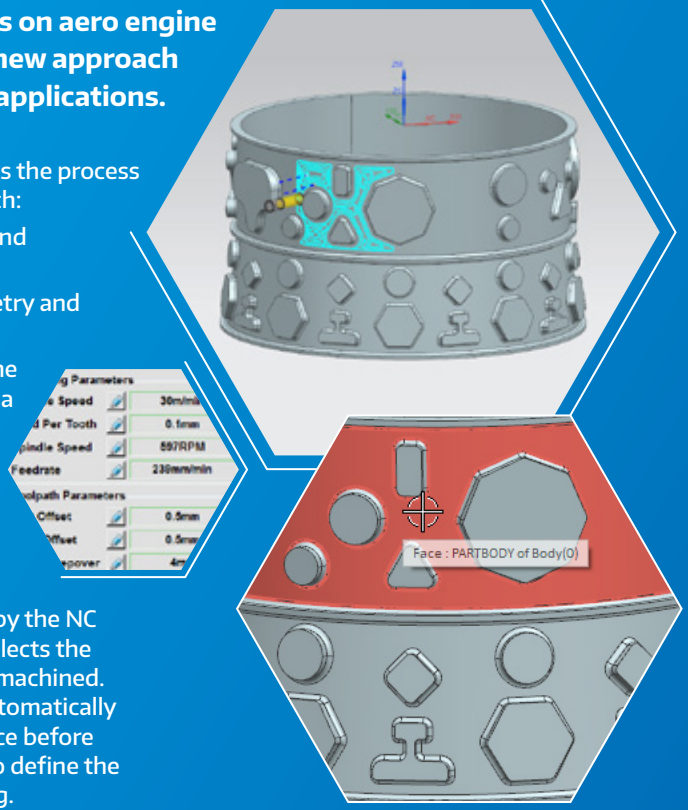
Existing CAD/CAM software can automatically create optimised tool paths for processes involving planar and contour milling like pocketing and profiling, but not for mill-turn operations like creating bosses on curved aerospace components.

That has to be done manually by an experienced NC Programmer and the process is so time consuming that producing an optimised path with the required cutting tool engagement is often compromised in a bid to save NC programming time.

AMRC Machining Group Technical Fellow Dr Robert Carroll took on the task of automating the process and rapidly came to the conclusion that a new approach was needed as current software wasn't really capable of automatically manipulating spline curves within a sketch and too likely to generate an error, requiring manual intervention to correct any issues.

Dr Carroll's solution breaks the process down into four steps which:

- Define the cutting tool and machining parameters
- Define the casing geometry and the area to mill turn
- Unwrap the surface of the 3D CAD model and create a 2D toolpath
- Wrap the 2D toolpath onto the surface of the 3D CAD model and create a 3D toolpath.



The first two steps rely on information provided by the NC programmer, who then selects the face of the cylinder to be machined. Dr Carroll's application automatically unwraps the casing surface before asking the programmer to define the area that needs machining.

Instead of generating a sketch and trying to automatically edit the curves, the application uses a combination of Siemens' integrated product design, engineering and manufacturing software, NX, and the integrated development environment for Microsoft's Windows operating system, Visual Studio, to generate a toolpath and convert it into a series of points that is used to create a two dimensional spline.

The spline is then wrapped back onto the casing surface and turned into the 3D toolpath that can be used to machine the bosses.

Trials using a Mori Seki 5-axis mill-turn platform and Sandvik Coromant solid carbide cutting tool have validated the new automated process, whose potential is described as "phenomenal," by Dennis Fretwell.

"You can have the entire 3D tool path in five minutes compared to the two and a half hours of the equivalent tool path manually created" says Fretwell. "It's a step towards a knowledge driven manufacturing system and it doesn't just work on cylinders, it also works on conical faces."

The Machining Group is now identifying future developments for the application - which could include turning it into a Siemens NX plug-in - and seeking partners who might want to support those developments.

> "Phenomenal. You can have the entire 3D tool path in five minutes compared to the two and a half hours of the equivalent tool path manually created."
>
> Dennis Fretwell, AMRC Machining Group technical fellow

Investment targets concerns over powder quality and optimising additive manufacturing processes

Rising interest in metal additive manufacturing and concerns about the variability of powder quality has prompted significant investment in new capabilities for the AMRC's National Metals Technology Centre (NAMTEC).

James Hughes, NAMTEC director. Kristina Parry, NAMTEC project manager. Adrian Sharman, NAMTEC project manager.

NAMTEC Director Dr James Hughes told AMRC partners attending its annual Tech Fellows conference the organisation had invested in laboratory capabilities and additive manufacturing (AM) technology.

The laboratory enabled NAMTEC to study a range of powder properties, including size, distribution and morphology, powder density, flow characteristics and chemical composition, as well as the composition of the surface and the bulk of the component.

"It is a unique capability, specific to powder technology," said Dr Hughes. "It enables us to examine powder characteristics to understand, predict and control the properties of powders, understand how to handle them and make best use of them, economically.

"We are also looking at processes themselves to determine how to optimise them so that you can produce a good quality, consistent product."

Initial studies are focusing on additive processes, but NAMTEC plans to look at other processes too.

NAMTEC is using thermal imaging of the melt pool formed when components are made using laser deposition to see what effect adjusting the energy of the laser has on the finished component and working with the AMRC's Machining Group to study hybrid additive and subtractive manufacturing.

Dr Adrian Sharman told conference delegates how NAMTEC was studying the characteristics of Gamma Titanium Aluminide (γTiAl) powders, produced by ball milling followed by gas centrifuge sieving and by gas atomisation.

Gamma Titanium Aluminide's light weight, combined with its excellent mechanical properties and resistance to oxidation and corrosion at high temperatures, make it a potential replacement for traditional nickel-based superalloys in aircraft engines.

However, the cost of producing powdered Gamma Titanium Aluminide by gas atomisation was quite high and while ball milling was cheaper, it produced an angular powder that included a lot of fines, which adversely affected its ability to flow.

Dr Sharman said NAMTEC had found removing fines significantly improved the flow of ball milled powders. The organisation had also studied the degree of cracking and porosity of components made from γTiAl powders produced by different methods.

Dr Kristina Parry explained how NAMTEC was testing the impact recycling Ti-6Al-4V powder had on build quality.

"We looked at the size and morphology and found it was pretty much stable as long as we kept the powder clean. The tensile strength was quite stable across 10 builds without heat treatment," said Dr Parry.

"Initially, the oxygen percentage rose, but after that it was pretty stable. We managed to make dense material, but it was very brittle."

Photography: Timm Cleasby

Research and new technologies open the way for stronger moulds and reduced costs

Matthew Cawood, AMRC Castings technical manager

A drive to increase the size, weight and as cast quality of titanium castings has fuelled research that has almost doubled the strength of ceramic moulds and could cut the time taken to make them from days to hours.

Increasing the size and weight of titanium castings meant the moulds needed to be strong enough to support themselves as well as the molten metal inside. They also had to be strong enough to cope with the additional stresses imposed by AMRC Castings' new titanium casting facility's capability to cast centrifugally.

"It's a balancing act involving strength, toughness, cooling, thermal expansion and shock resistance," AMRC Castings technical manager Matthew Cawood told the Tech Fellows conference.

"At 1750°C the thermal shock can be high. We are doing quite a lot of work, trying to engineer the system to build a mould with different layers that complement each other and withstand thermal shock and we have been trying to pour into moulds at room temperature to increase cooling rates and give a better microstructure."

AMRC Castings has been working on mould strength optimisation and has almost doubled the strength of standard alumino silicate moulds by modifying the chemistry of materials used for standard titanium shells and is installing in-line equipment to monitor and verify mould production which could help it optimise mould parameters and drying times.

The organisation has developed new mould coatings that have at least halved amount of alpha case, the hard and brittle layer that forms on titanium castings and has to be removed by machining or chemical milling.

Meanwhile, a new process being developed by AMRC Castings for drying ceramic moulds using microwaves could radically reduce the time it takes foundries to produce them.

"The drying process often determines the quality of the mould," said Cawood. "A typical investment mould can take up to three days to produce a mould and we are trying to bring that down to an hour."

...from **DAYS** to **HOURS**

3D printing offers opportunity to cut the manufacturing times, weight and costs of aerospace tooling

Matthew Cawood, AMRC Castings technical manager

AMRC Castings is aiming to cut the costs and time it takes to produce the tooling needed to make aircraft wings.

The organisation says lead times for producing lightweight cast aerospace wing tooling from Invar - a nickel–iron alloy with a low coefficient of thermal expansion - could be cut by 89 per cent if moulds were made by 3D printing with sand.

It also says that by optimising the shape of the cast tooling, it could be 23 per cent lighter and 38 per cent cheaper than current fabricated tooling.

Another area of research aims to develop ways of improving the integrity of castings made from alloys which can be melted in air by contact pouring into ceramic moulds.

Conventionally, molten metal is poured over the spout of a ladle into the mould. Contact pouring reduces the turbulence and contact with the air which produces defects by using a ladle with a gate in its base that is put in contact with the mould so that, when the gate is opened, the molten metal enters the mould without passing through air.

"Ceramic moulds are generally used in aerospace, but their fragility means they don't lend themselves to contact pouring techniques," explained Cawood.

"The main challenge is how to get a seal between the ladle and the ceramic mould that prevents air being drawn in to the gating system.

"Ceramics don't like shocks or loading so we have used design and engineering to accommodate the force changes and we have designed a gasket that provides an optimum connection and seal between the mould, down sprue and ladle nozzle."

AMRC Integrated Manufacturing Group has ambitious plans to help the UK become an

Industry 4.0 centre of excellence

L: Ben Morgan, head of IMG. R: Chris Greaves, IMG operations manager

Head of the AMRC Integrated Manufacturing Group (IMG), Ben Morgan told delegates that although approaching 50 members of staff, the group was still recruiting since moving into its new home at Factory 2050.

This was down to increasing orders and expanding and upgrading capabilities in collaborative robotics, flexible fixturing, robotic machining and mixed reality technologies. In 2016 IMG also held its Industry 4.0 conference, Factory 2050: The Smart Factory, which generated multiple projects thanks to engagement with over 150 delegates from multiple sectors.

IMG Operations Manager Chris Greaves said the aim of the group is to grow and develop its digital manufacturing capabilities and expand further into new sectors such as civil engineering.

Major research projects being undertaken include exploring how augmented reality can be used to project live data onto real components to analyse assemblies 'on the fly', comparing physical builds to CAD data live.

Rapid in-process composite part inspection is also being explored. Usually difficult to conduct without surface preparation, IMG is trialling the use of emerging scanning techniques alongside robotic assembly, to quickly and efficiently move parts for measurement and analysis.

IMG will also be modelling live data in an interactive digital twin to create a 'digital master' to view a 38 axis fixturing cell. Exploring data analysis will provide the ability to predict production inefficiencies, validate manufacturing processes and plan schedules.

Chris Greaves told delegates that Catapult funding will allow IMG to conduct research into robotic machining: "Using our re-designed, upgraded and newly installed KUKA Titan robot, will allow us to produce detailed methodologies for robotic machining and benchmark against other machining methods to prove accuracy."

"We want the AMRC to become a centre of excellence in the development of ideas and solutions to real manufacturing problems through the implementation of industry 4.0 technologies," he added.

Integration of disparate software platforms is the key to gather and process 'big data'

Alex Godbehere, IMG systems engineer

Underpinning the rise and adoption of Industry 4.0 technologies is the need for disparate software systems to share data in the same language, from a wide variety of sources.

"This will make it easier to access and analyse, improving the value of 'big data'," Controls Tech Lead, Adrian Hirst told conference delegates.

IMG investigated how to integrate various server based data gathering and visualisation systems and explore emerging technologies for control and acquisition of data from devices such as low cost sensors.

The team integrated Siemens WinCC SCADA, a supervisory control and data acquisition system with PTC ThingWorx, an object orientated Internet of Things platform.

SCADA interacts with controllers at low level and is reliable for centralised monitoring, but is dated and slow, so not ideal for large volume metrology applications. ThingWorx is a modular system with lots of connectivity options, great for rapid development, but is unproven in manufacturing environments.

Trialling a variety of integration methods, the team found that using a centralised MS SQL architecture with an interface that sits between the device and the database was highly compatible with a lot of devices. Although it required additional programming, it used one language and one set of data calculations, simplifying gathering of data.

Systems Engineer, Alex Godbehere said that the project ended with both systems fully installed and configured across multiple cells on the Factory 2050 workshop floor: "The integration allowed successful data transfer between two disparate software systems.

"We can integrate additional systems with data being centrally gathered, which will contribute to machine learning and data analytics; this helps us to understand production quality and perform predictive maintenance.

"This effectively creates a digital twin of an entire manufacturing process for real time monitoring and the project is scalable for the future expansion of Factory 2050."

Mass customisation of products requires a reconfigurable factory floor

Dr Lloyd Tinkler, IMG control and systems engineer

Industry 4.0 is all about the demand for mass customisation of products and the AMRC's Factory 2050 is all about bespoke and reconfigurable manufacturing, Dr Lloyd Tinkler told conference delegates.

He said the key to creating a reconfigurable factory is to pick and choose your business model before your competitors, by understanding what technologies you require to drive your business forward.

Conducting a study into the reconfigurable factories of the future, Tinkler found that many of the technologies needed to create this kind of production environment already exist. The challenge is to integrate disparate systems that reconfigure fixtures, track products and gather data to help optimise production processes.

"Creating a small scale demonstrator to produce and extract data for use in manufacturing analytics during an automated assembly process, showcasing the technologies needed to create a fully-reconfigurable production environment," said Tinkler.

The demonstrator consisted of a table top 'factory floor' made from plates which could be reconfigured to accommodate cabling, a small ABB IRB 120 robot equipped with a WWR series tool changer from Zimmer. A server based application tracked the NFC tagged components whilst communicating with the hardware via MQTT, an open-source Internet of Things protocol, to assemble a small product.

"The demonstrator helps manufacturers understand the technologies they can use to using to fully embrace Industry 4.0 manufacturing techniques," Tinkler told delegates. "Showcasing technology that you can unplug and move around, which can be scaled up, tracked, operate across platforms and produce customised products."

The project was now going to be scaled up to include research into manufacturing informatics to optimise and self-configure task allocation in a reconfigurable production environment.

Factory 2050 demystifies emerging digitally assisted assembly technologies

Michael Lewis, IMG augmented reality developer

Conference delegates heard that IMG are working to help industry partners make informed decisions about the early adoption of technologies.

IMG's Digitally Assisted Assembly team aim to demystify emerging augmented, mixed and virtual reality technologies, by developing shop floor demonstrators at Factory 2050.

"Projects such as our projection mounting system and large scale reconfigurable frame to hold and fixture an A380 wing section for large and small scale fixturing projects, show visitors how easily it can be adapted for other component models to address rapidly changing customer demand," Michael Lewis, Augmented Reality Developer for IMG told delegates.

Visitors to the AMRC's Factory 2050 have the opportunity to engage with a wide variety of virtual, augmented and mixed reality technologies, before some are even commercially available, such as the Microsoft HoloLens.

"We want to provide partners with business use-cases to assist decision making about early adoption of these technologies and how they are applicable to a manufacturing environment, added Lewis.

"Working with mixed reality technologies such as the HoloLens, we are developing ease of access via its environmental mapping feature for a full mixed reality workspace. The technology allows information for assembly processes to be displayed in real-time whilst interacting with a physical environment or component."

Non-conventional machining helping UK companies re-shore manufacturing skills

Lisa Alhadeff, AMRC Industrial Doctoral Centre student

Watch-maker Bremont is exploring the use of non-conventional machining methods, with the aim to manufacture chronometer watches from entirely British-made components.

AMRC Industrial Doctoral Centre student Lisa Alhadeff is sponsored by Bremont to research the manufacturing processes involved in micro-machining.

Using the Kern EVO micromill and Mitsubishi MV4800, Alhadeff has conducted machining trials based on the micro-machining of novel alloys using micro-milling and wire electrical discharge machining (WEDM), processes both capable of producing intricate geometrical shapes to high tolerances.

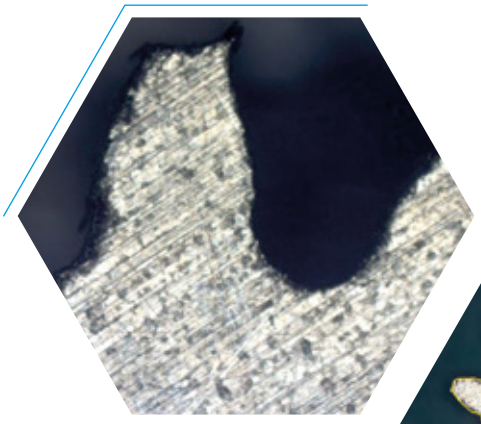
Alhadeff said: "The goal was to optimise the cutting parameters of each process, using surface quality as a measure of quality during the machining of micro components."

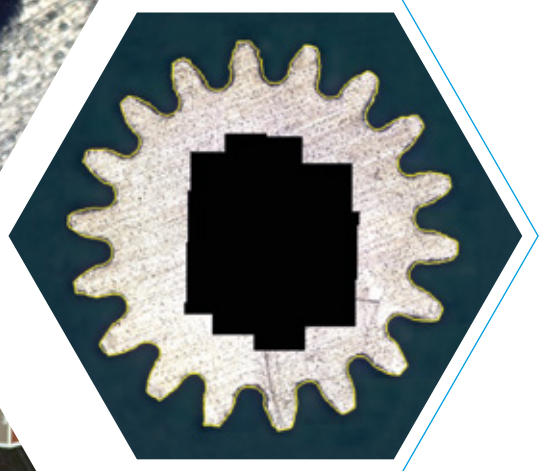
WEDM uses a thermo-electric effect to remove material from a workpiece and the process has a huge number of variables, including the wire tension and machining voltage used. Altering any combination of variables can increase the material removal rate but leads to poorer surface generation rate, or vice versa.

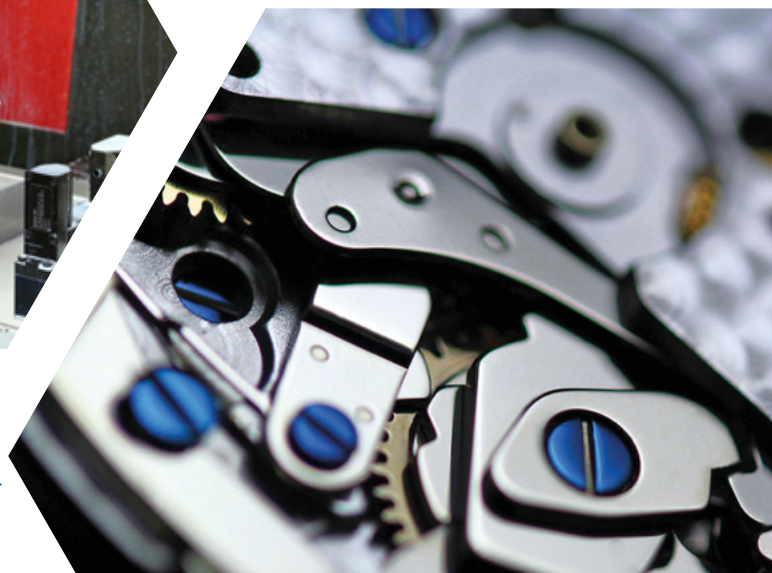
Some initial work on parameter optimisation revealed a surface finish roughness average value that was almost an order of magnitude smaller than that initially achieved. This indicates that WEDM could be a viable method for manufacturing high definition components such as the dies for cutting gear blanks and thin low stress parts that require zero finishing.

Micro milling is of interest due to current processes contributing to significant wear of the delicate tools and adhesion, even after just 30 minutes machining time; this in turn generates a surface finish with defects.

Alhadeff hoped monitoring and making adaptations to cutting forces will optimise micro-milling processes for the industry. Her future work will include harnessing the two technologies described to develop various higher-tech watch parts, as Bremont continues on its journey to being an entirely in-house watch movement manufacturer.







Reducing manufacturing times of aerospace components by optimising finish machining processes

Adam Cox, AMRC Industrial Doctoral Centre student

AMRC Industrial Doctoral Centre student Adam Cox is conducting research on behalf of the Safran Landing Systems – part of the Safran Group – to reduce finish machining time for aerospace landing gear components.

Adam discussed the complexity of high speed titanium machining for new aircraft platforms with delegates and the significance of the production time involved for fabrication of such components. The project focuses on the potential for cost reduction in Safran's manufacturing processes and opportunities for implementation of advanced technology.

Machining trials focused on improved cutting conditions, tooling and the use of advanced characterisation techniques for finish machining the titanium metastable beta alloy Ti-5Al-5V-5Mo-3Cr. Such alloys offers significant mechanical advantages but bring new challenges due to low machinability and variations in composition.

To address this Adam focused on how cutting speed, feed rates and tool wear affected performance, using surface generations rates and fatigue performance as indicators of material integrity. Small scale testing methodologies were developed to accurately replicate industrial machining processes and a bespoke four-point bend fatigue test was designed and utilised to study the implications of machining induced deformation on in-service performance of Ti-5553.

A variety of data-gathering techniques, including in-process monitoring produced a wealth of qualitative tool and machinability data, which assisted Adam in optimising and improving machining processes and reduce the time it takes to finish machine these aerospace components.

Using advanced characterisation techniques for finish machining the titanium metastable beta alloy

COMPOSITE MACHINING FORUM

Composites must offer significant advantages over other materials to justify their choice

Austin Cook, BAE Systems

Composites present aerospace companies with significant challenges that make them expensive to process and limit their use to applications where they offer significant advantages over other materials.

However, trends fuelling demand for specialised, bespoke components and larger, unitised parts could lead to increased use of composites in future, Austin Cook, from BAE Systems told an AMRC Forum on machining composites.

"We are potentially moving towards a world of larger composite parts, larger skins and fuselage parts and are looking at advanced joining techniques instead of drilling and filling," said Cook.

Making components from composites was highly labour intensive and companies had to take significant steps, including continually rotating staff, to avoid repetitive strain issues, because automated processes and technologies could not meet the demands posed by the need to use high performance composites.

Companies also needed to develop a greater understanding of the machining process when composites were involved, not least because of the need to restrict the rise in temperature and the fact that composites could absorb moisture and water.

Cook told the Forum BAE Systems was working with the AMRC to understand:

- Which coolants might be used
- How large volume machining using robots and waterjet machines could be employed
- How smart cutting tools, incorporating micro sensors, can be used to avoid damage to composite components during machining, reducing cutting tool cost

There was also potential for cryogenic machining, but that meant there was a need to understand the effect cryogenic cooling might have on the performance of coated cutting tools and the geometry of the cut.

Water jetting was currently mainly used for trimming, but the trend towards making smaller numbers of larger components could broaden its use, if fixturing solutions could be developed which were lower cost or would not be destroyed by the water jetting process.

Cook also highlighted the work BAE Systems had done with the AMRC to develop a flexible cell using two robots to countersink holes in around 90 different carbon fibre components for the F-35 Joint Strike Fighter with dimensions ranging from three metres to the size of an A4 sheet of paper.

Future developments could include drilling as well as countersinking, he predicted.

Imaging technology helps to uncover the hidden secrets of tool wear

Brian Kyte, Alicona

Wear measurement plays a vital role in controlling the composites machining process but tool features can be small and geometrically challenging to measure, while the surface roughness of the component can impact performance and edge rounding is critical.

Researchers from the AMRC's Composite Centre have been using Alicona Imaging's metrology technology to measure cutting tools for the past five years.

In 2016, the AMRC acquired an Alicona InfiniteFocus G5 non contact optical 3D surface characterisation and measuring tool, which performs 3D Measurements directly on the optical image, from which it generates a single 3D data set with accurate topographical information.

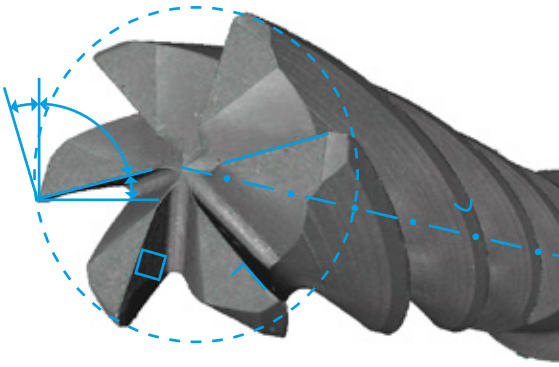
Brian Kyte, from Alicona, told the forum the company had done a lot of collaborative work with the AMRC on edge and in-process measurement to increase understanding of tool wear characteristics.

"Standard tests cannot be used for tools used with composites, where you need to measure web width, helix angle, rake angle..." said Mr Kyte.

"The AMRC takes a model of the tool prior to use and, after use, you can directly measure the wear and start to control the process.

"We can measure down to two micron and up to millimetres, which means we are able to measure coating removal and damage caused by it."

By evaluating tool parameters and wear, the AMRC has been able to get a much better understanding of what the ideal tool parameters should be and can now see huge potential for using Alicona's technology to explore thermal effects of tools machining composites.



Multiple measurement locations shown on an optical image of a round tool

Cutting through composite machining challenges with diamonds and design

Hiro Takikawa, OSG

Cutting tool manufacturers are responding to the challenges of machining composites with a combination of tool design and the development of special coatings, according to Hiro Takikawa, from cutting tool manufacturer OSG.

Takikawa told AMRC Forum delegates that the structure of Carbon Fibre Reinforced Polymer (CFRP) created particular problems in machining.

Although the fibres had a high tensile strength, the fact that they were bonded by resin meant the strength between carbon fibre tows was low, which could lead to delamination, burring, uncut fibres, hole expansion, rough surfaces and thermal damage.

CFRP was very abrasive and difficult to machine. Tools used to machine CFRP were prone to wear quickly, while cutting temperatures could be high. Meanwhile, parts tended to generate chatter and suffer spring back.

All this meant machining costs were high and one of the most important priorities was to bring them down.

Tools used to cut CFRP needed to have sharp cutting edges and exert low cutting forces. Since tool wear was generally abrasive, tool life was in proportion to the number of cutting edges, but maximising cutting edges could also raise cutting forces.

Emphasising the important role tool design played, Takikawa said tools also had to be designed to avoid leaving uncut fibres and suppress delamination by ensuring forces were reduced and distributed in such a way that they pressed down.

When it came to coatings, OSG had developed an ultrafine diamond coating with a grain size of around one micron, similar in size to tungsten carbide's grain size, and with a high adhesion strength on a tungsten carbide substrate.

Comparisons between the company's ultra-fine diamond coated D-STAD tool and a tool made of Sintered Polycrystaline Diamond (PCD), showed that while the quality of the exit hole after the 800th hole produced by the D-STAD tool was still much better than the quality of the PCD tool had deteriorated after the 200th hole had been drilled.

Not only did using the ultrafine diamond coating increase wear resistance and reduce tool costs it also allowed greater freedom to optimise the geometry of the tool.

Left: Diamond Coated Nicked Router
Right: Diamond Coated Rougher

Rising to the challenge of optimising composite machining strategies

Glass transition temperature, or Tg as commonly referred to by polymer scientists, could be the key to choosing the right set up for machining composites in the future, according to Dr Kevin Kerrigan.

Dr Kerrigan, technical lead researcher for machining, AMRC Composite Centre

Dr Kerrigan, technical lead researcher for machining, within the AMRC Composite Group, told delegates to the AMRC Forum: "I expect that, in years to come, composite machinists will be asking designers what Tg and degree of cure the resin material has. This will drive the process of determining optimal cutting strategies with which to generate the perfect composite hole, edge or surface."

Listing the challenges involved in machining composites, Kerrigan said cutting tool manufacturers had done tremendous work on optimising tool geometry and abrasive resistance to more efficiently generate material removal and enhance tool life on composite products – which was significantly different from metallic machining processes generating micro- and nano-scale chip.

Carbon fibre reinforced polymer (CFRP) chip in particular presents health and safety challenges to the operator and factory community as well as nearby electronics and mechanical moving parts. Currently in CNC applications, either full-flood cutting fluid is used to damp the dust cloud generated during machining or, alternatively, powerful, energy hungry extraction systems are required to remove the airborne dust cloud. This dust cloud has the additional risk of causing an explosion if not correctly dealt with. In more manual machining operations, such as in-situ hole drilling on large wing sections, MQL is applied via an automated drilling unit to suppress the particulate generate and prevent operator exposure. The downside of MQL in CFRP applications in particular is the carbon/oil abrasive paste formed can lead to aggressive tool wear.

High sharpness was very important, but tools could wear very quickly. Different fibre orientations could affect chip formation and surface roughness, overheating could result in chips re-bonding to the surface and a range of factors could lead to plies and fibre separating from the resin, resulting in fibre pull-out, fraying and delamination.

Researchers at the AMRC Composite Centre were investigating ways of characterising different composite materials, the effect on process parameters such as force and temperature of using different cutting tool designs on a range of materials with different fibre orientations, the role temperature played and changes in the curing process.

"It is necessary to consider the fundamental behaviour of polymer-based composite materials during cutting interactions – the glass transition temperature is extremely important in this regard," said Kerrigan.

AMRC Composite Centre researchers were also looking into the fundamental mechanisms of both mechanical and thermal damage formation during CFRP drilling investigations by pushing the boundaries of parameters such as cutting speed, feed rate and tool geometry. The results indicate routes to novel solutions which could avert damage and increase tool life. Another avenue of research at the AMRC is comparing the composite edge trimming and drill/countersinking capabilities of a CNC machine tool and a robot, using the same cutting tool.

The robotics industry is currently experience some popularity for CFRP machining processes as composite applications require more and more dexterous and accessible machining operations to meet design requirements. Limitations in the use of currently commercially available robotic platforms include spindle excitation effects on dynamic stiffness and multi-axis system accuracy which have been investigated at the AMRC recently. By studying the robot's frequency response function, looking at ways of damping excitation and correcting the tool path using iterative feedback loops, researchers have found that the robotic cutting solution performance can achieve nearly comparable accuracy results when compared to CNC machine tools with tolerances in the order of hundreds of microns.

Kerrigan also mentioned that there is also a drive within the composite manufacturing community to develop innovative methods by which to generate accurate net shape composite components without the need to perform any machining operations and recommends that this is a research direction which warrants further investigation over the next decade in terms of cost benefit with growing global trends towards making composite manufacturing more affordable and sustainable.

Challenging the assumptions of composite part setup

Innovative technology that allows accurate machining on complex metal parts is also being employed to successfully machine composites.

Peter Hammond, Metrology Software Products Ltd

Metallic forming processes often produce parts that are incredibly difficult to align and easily distort in fixtures, issues that are echoed within composites machining.

Peter Hammond, from Metrology Software Products Ltd (MSP), told the AMRC Forum how MSP developed software to solve these problems experienced by BAE Systems when attempting to machine superplastic-formed foreplanes, for the Eurofighter Typhoon.

Each part had to be secured to an expensive, custom fixture on a pallet in order to machine the foreplane's leading and trailing edges. Slight errors during the manual setup process or movement during the clamping and unclamping stages meant that every foreplane was never in the exact, identical position as the one before and lead to incorrect machining.

MSP's answer was to use on-machine probing to work out the exact orientation of the part and then automatically re-align the cutting program to ensure it was machined accurately.

"You don't need to accurately locate the part, just find it with the probe," Peter Hammond explained.

Putting measurement on the machine tool allowed manufacturers to verify that their machine was capable of accurately cutting the part, removing the need to wait for delayed part inspection.

This technology enabled the use of innovative, lower-cost fixturing solutions that reduced set-up time, could be used on more than one machine and, in the case of "sticky fixturing", lessened stress to minimise distortion. These "sticky fixtures", where a part is temporarily glued into placed to be machined, also allow for accurate mechanical alignment as there is no stress on the part due to hard clamps.

"We work with a lot of Formula 1 teams who use this technique every time they produce a front wing for a Formula 1 car," said Hammond. "Often, the aerodynamics of the wing are unique to the track it is being used on. In a former life, they had to machine female moulds, now they use body filler to hold the part."

Transferring the technology of MSP's successful work with complex metals to composites machining has challenged the assumptions of working with this difficult process and provided manufacturers with high value cost and time savings.

Getting good vibes about upping tool life and cutting speeds

Kevin Jones, DMG Mori

Ultrasonic milling technology could make a significant contribution to extending tool life, increasing speed and feed rates and improving surface finish when processing composites, Kevin Jones from machine tool manufacturer DMG Mori told the AMRC Forum.

Jones said the technology developed by the firm's advanced technologies operation, Sauer, reduced the forces cutting tools were subjected to and was being integrated into the rest of the group's machines.

The technology had been employed in the optical, watch making, fine mechanics, technical ceramics, dental, medical, superalloy and composites field where it was being used to produce components for the aerospace, motorsport, automotive and renewables sectors, amongst others.

While first generation toolholders for ultrasonic machines were capable of movements of three to five microns, the new generation had raised that to 10 to 15 micron at frequencies of 20 to 50 Hz.

Using ultrasonics had trebled feed rates for materials such as Inconel and resulted in a five-fold increase when machining magnesium.

Meanwhile, the sawing action produced by ultrasonics reduced the risk of composite components being weakened by carbon fibres being pulled out during machining.

Image: DMG Mori

ROBOTIC STIFFNESS AND SPINDLE AGEING SEMINAR

AMRC intern's projects identify future directions for robot and machine tool spindle research

Opportunities for further research into the way a machine tool spindle's age affects cutting performance and understanding how to compensate for the inherent errors in robots have been highlighted by projects carried out by AMRC intern Adrian Leung.

Adrian Leung, AMRC intern

Leung laid the foundations for studying the dynamic changes in spindles over time, which could lead to ways of making automatic adjustments during the spindles life.

His investigations included identifying how long machines needed to be run to guarantee the repeatability of tap test results and the effect bearing orientation has on the tap test results.

His project also highlighted the potential benefits of training machine operators to carry out tap testing as part of a regular maintenance plan.

Leung's preliminary investigation into compensating for the errors affecting the use of robots for machining was prompted by beliefs that manufacturers will increasingly want to use them as a low cost alternative to machine tools.

"Robots are going to play a huge part in the future because they are cheaper than large, conventional CNC machines, can operate in a large workspace, are adaptable and can easily be reconfigured," Leung told a seminar in the AMRC's Knowledge Transfer Centre.

"However, they have low stiffness values and their stiffness is very posture dependent."

Leung developed a test system using a force cell in an adaptable vice and laser sensors to allow him to apply specific forces to the end effector – the tool holder at the end of a robot's arm – and measure the end effector's displacement.

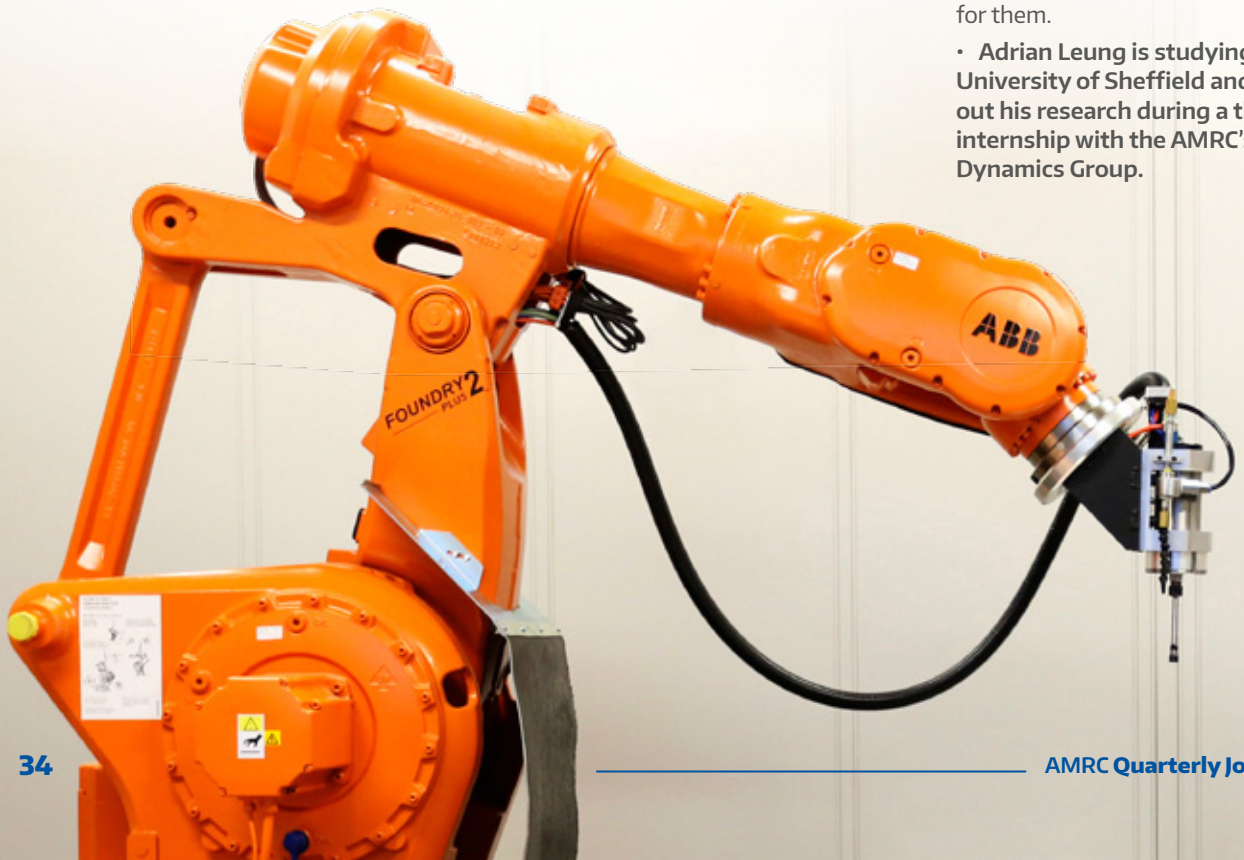
He investigated different ways of applying the force, to ensure the simplest – continuously increasing the force – provided results as accurate as more complex methods of increasing the force by incremental steps and releasing and reapplying the force each time it was changed.

Leung also confirmed that a robot becomes stiffer along one axis as the arm extends in that direction and identified similar trends in the way the stiffness of the joints of different robots changed during movement.

His project was designed to collect force data in four separate locations on a machine bed. Future steps are likely to include taking measurements in more locations and carrying out cutting trials using different feed rates to see how that affects accuracy.

The long term aim of the programme is to understand the errors inherent in robot machining and develop predictive models that automatically compensate for them.

• **Adrian Leung is studying at the University of Sheffield and carried out his research during a three month internship with the AMRC's Machining Dynamics Group.**



AMRC Training Centre **Courses**

For further information please contact **cpd@amrctraining.co.uk**
View all scheduled courses at **amrctraining.co.uk/course-calendar**
All courses held at the AMRC Training Centre, Rotherham, unless stated otherwise.

May 3rd
Apprentice Mentoring: Engineering the Next Generation
Employing apprentices is a useful way to grow your business and plan for the succession of staff.

May 9th
Principles of Heat Treatment
This course outlines the basic metallurgical principles of heat treatment, the fundamentals of furnace design and operation and concludes with an explanation of testing and quality control procedures.

May 22nd – 25th
City & Guilds 17th Edition IEE Wiring Regulations (2382-15)
The AMRC Training Centre always looks to add value to the learning experience to benefit both the employer and learner.

May 23rd
Testing Techniques
A technical course describing the techniques used to determine the mechanical properties of metals and for non-destructive testing (NDT) of structures and components.

June 6th
Quality & Quality Control
A one day training course addressing the key aspects of Quality from the perspective of engineering services and product manufacture.

June 20th – 21st
Metallurgy for Non-Metallurgists
The course aims to provide a sound understanding of the scientific principles of metallurgy and how to apply them to specify and process metals in an industrial context.

June 27th
Metals Processing & Manufacturing Technologies
This course outlines the primary and secondary processing of the major industrial metals and the downstream processes used to engineer finished components.

July 3rd – 7th
Introduction to MIG/MAGS Welding
A five day introduction to the basic concepts of MIG/MAGS welding, and typical applications in today's modern engineering environment.

July 10th – 14th
Introduction to TIG/TAGS Welding
A five day introduction to the basic concepts of TIG/TAGS welding, and typical applications in today's modern engineering environment.

July 11th
Non-Ferrous Alloys
A technical course describing the production, features and applications of aluminium, copper, nickel and titanium alloys.

July 25th
Metallurgical Failure Analysis and Prevention
This course will enable delegates to determine how and why a metal component has failed or fractured during service and identify means of detecting and preventing such failures in the future.

September 5th
Carbon & Alloy Steel Metallurgy
This one day course has been developed for people with technical and engineering backgrounds working in or with the steel industry to help them gain an understanding of the metallurgy and processing of carbon and alloy steels.

AMRC **GRINDING CONFERENCE**
at the AMRC Knowledge Transfer Centre

This conference will reveal the extent to which grinding is already being used as a mainstream machining process, discuss the technical and commercial challenges involved and examine the trends and experience of end-users and equipment providers.

Save the Date **OCTOBER 4th - 5th**

New **partners**
at the AMRC with Boeing

AECOM is an American multinational engineering firm that provides design, consulting, construction, and management services to a wide range of clients.

Autodesk is a leader in 3D design, engineering and entertainment software.

For over 90 years **Ceratizit** have been developing and producing sophisticated hard material cutting and wear protection solutions.

GKN Aerospace is one of the world's largest independent first tier suppliers to the global aviation industry.

Greenleaf Corporation develops and manufactures high-performance cutting tools and components.

Iceotope is the home of cutting edge liquid cooling technology. Designed and manufactured in the UK.

McLaren Automotive is a British manufacturer of luxury, high-performance sports cars.

Plataine is an award-winning leading provider of intelligent automation solutions for advanced manufacturing of various industries.

PTC is a global technology provider of the leading IoT and AR platform and field-proven solutions transform how companies create, operate, and service products.

Ricardo is a global engineering and strategic, technical and environmental consultancy business.

Sumitomo Electric group provides a wide variety of carbide, CBN and diamond cutting tools and tool engineering services.

Zimmer Group is among the leading manufacturers in the automation industry for mechanical and plant engineering products.

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The Queen's Anniversary Prizes 2007