quarterly journal

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The University Of Sheffield.

Advanced Manufacturing Research Centre

BOEING

In control for the next **industrial revolution**

Industry 4.0
Discovering the implications of 'Industry 4.0' for manufacturers at AMRC event

Factory 2050
Pioneering data driven, digital factory nears completion as the AMRC continues to expand

Innovation Centre
World-leading manufacturer Nikken opens Innovation Centre at the Advanced Manufacturing Park

CATAPULT
High Value Manufacturing

EUROPEAN UNION
Investing in Your Future
European Regional Development Fund 2007-13

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Welcome to our new look

quarterly journal

The Journal began life spreading news about the work of the AMRC's National Metals Technology Centre (NAMTEC), much of it funded by the European Regional Development Fund.

Following the completion of NAMTEC's ERDF-funded projects and its change of emphasis, to focus on materials and powder technologies, we've decided the time is right to expand the journal's coverage to include all of the AMRC's work. The timing couldn't have been better, given the major developments that are underway here.

As you will see from this issue, our ground breaking, multi-million pound Factory 2050 development is nearing completion.

Factory 2050 is the first development on what will be a brand new, second AMRC campus, close to our existing base. It will be the UK's first fully reconfigurable assembly and component manufacturing facility, carrying out collaborative research and will play a key role in helping UK companies, both large and small, reap the benefits of Industry 4.0 technology.

Those benefits were discussed at a seminar, hosted at our Knowledge Transfer Centre, with one speaker predicting that, with the right investment, Britain could be back in manufacturing's driving seat and spearheading a fourth industrial revolution.

Putting UK companies in the driving seat is what underpins further investment, underway at AMRC Castings and designed to enable UK companies to break into global markets for large-scale titanium aerospace engine and structural components. The market for these components, weighing up to 500kg, is currently served by a handful of players, none of them in Western Europe, so there are key opportunities.

We're also delighted to have started work on building the world's first 3D printing machine, capable of making plastic parts up to three times larger and 100 times faster than current comparable additive machines.

It's also capable of challenging conventional injection moulding for high volume production.

The machine is based on technology developed by Professor Neil Hopkinson from the University of Sheffield's Faculty of Engineering and is being built by our Design and Prototyping Group.

As you will also read, we've been honoured to host a meeting where research affiliates from the world-leading organisation in production engineering research, The International Academy for Production Engineering (CIRP) exchanged information on some of the latest developments in their fields.

So much has been happening and so much more is about to happen thanks to the continuing support of our increasing band of partners and financial backing from the government, High Value Manufacturing Catapult, HEFCE, ATI, EPSRC, ERDF and others.

Prof Keith Ridgway, CBE.
Executive Dean of the
University of Sheffield AMRC

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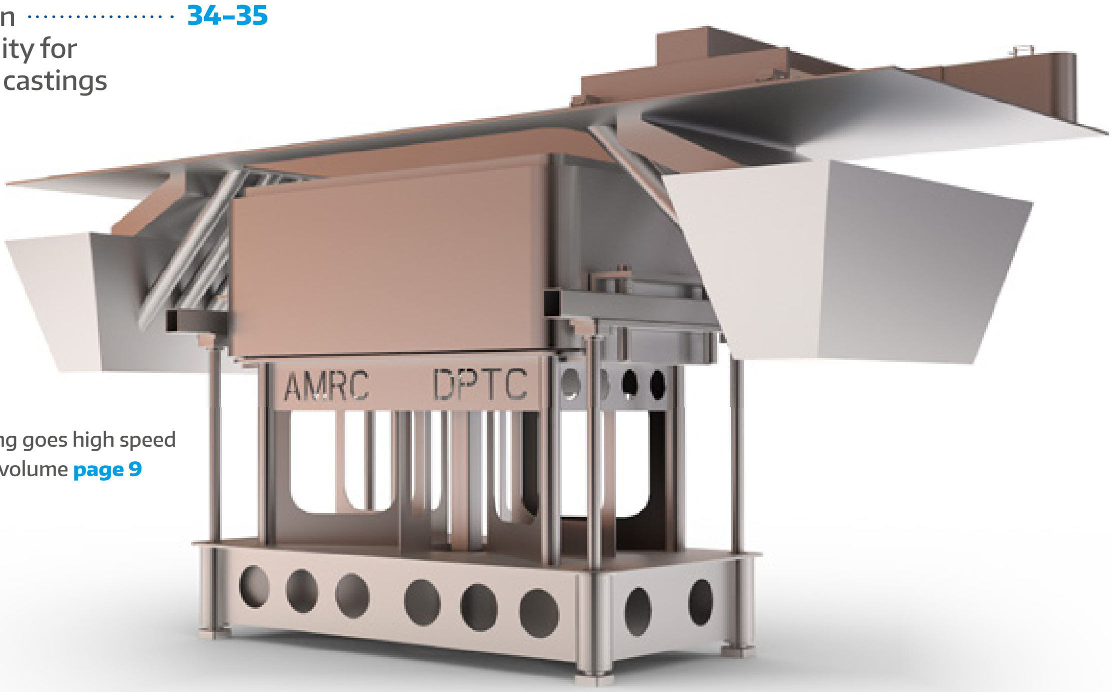


3D printing goes high speed and high volume **page 9**

The Siemens electric motor weighs just 50KG and delivers a continuous output of about 260 kilowatts – five times more than comparable drive systems.

SIEMENS AND AIRBUS PLAN TO BUILD ULTRA-QUIET HYBRID AIRCRAFT

Siemens and Airbus are aiming to create an aircraft powered by an ultra-quiet hybrid engine, capable of carrying up to 90 passengers.

The aircraft, which could be flying by 2035, will use a small jet engine, a battery and an electric motor to drive propellers and could use up to 50 per cent less fuel than a conventional aircraft.

Earlier this year, Siemens announced researchers had developed a new type of electric motor that weighed just 50 kilograms and had a continuous output of about 260 kilowatts – five times more than comparable drive systems.

The motor had been specially designed for use in aircraft and Siemens said that, thanks to its record-setting power-to-weight ratio, larger aircraft with take-off weights of up to two tonnes would be able to use electric drives for the first time.

Siemens says its motor has a power-to-weight ratio of 5kW/kg, which is five times higher than a normal industrial motor and can drive propellers directly, without the use of a transmission.

The motor produces enough power to fly a four-seater aircraft with a take-off weight of two tonnes, when used in conjunction with a small jet engine and is scheduled to begin flight-testing before the end of the year.

Siemens says the hybrid design allows the aircraft to use additional power from the battery while taking off and climbing quietly. It would then switch to using power from the jet engine.

"This innovation will make it possible to build series hybrid-electric aircraft with four or more seats," said Frank Anton, head of eAircraft at Siemens Corporate Technology, the company's central research unit.

"We're convinced that the use of hybrid-electric drives in regional airliners with 50 to 100 passengers is a real medium-term possibility."

Alcoa grows its multi-material aerospace portfolio by acquiring titanium specialist RTI

Lightweight metals specialist Alcoa has completed the acquisition of RTI International Metals, the global leader in titanium and specialty metal products and services for the aerospace, defence, energy and medical device markets.

RTI's titanium operations include melting, ingot casting, bloom, billet, plate and sheet production; manufacturing extrusions for aerospace, oil and gas applications, high speed machining, and production of integrated sub-assemblies primarily for aerospace.

RTI's acquisition expands Alcoa's additive manufacturing capabilities into producing 3D-printed titanium, specialty metals and plastic parts for aerospace, medical and energy applications.

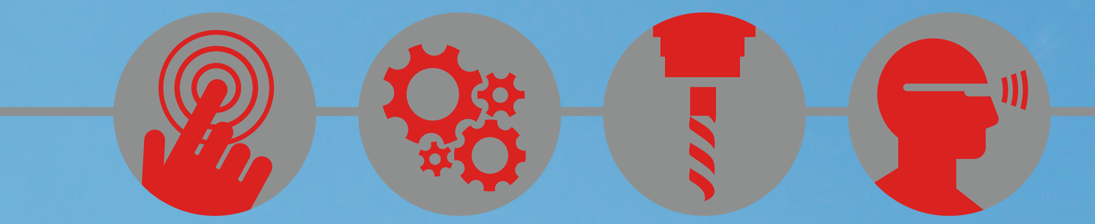
Alcoa itself has titanium investment casting and forging capabilities, and says the deal will allow it to create a closed titanium scrap loop, which will add value to the group.

It expects the acquisition will increase Alcoa's 2014 pro forma aerospace revenue by 13 per cent to $5.6 billion. RTI recently secured a contract with Airbus for finished titanium structural supply parts for the new A350-1000 aircraft programme. Under the agreement, Alcoa will supply titanium parts for the fuselage, among other components.

RTI will be renamed Alcoa Titanium & Engineered Products.

Alcoa has been aggressively growing its aerospace business. Last year, the company completed the acquisition of leading global jet engine component producer Firth Rixson and in March, Alcoa completed the acquisition of TITAL, a leading manufacturer of titanium and aluminium structural castings for aircraft engines and airframes.

NIKKEN Innovation Centre opens at the AMP



NIKKEN Kosakusho, the world-leading manufacturer of NC tooling and CNC rotary tables, are now resident in their new Innovation Centre at the Advanced Manufacturing Park (AMP).

The Innovation Centre demonstrates an ongoing commitment to High Value Manufacturing for Nikken, with the investment being made to develop and demonstrate the advanced machining techniques capable with Nikken products on a wide range of different machine tools housed in the purpose-built setting.

The new innovation centre is a blueprint facility for the NIKKEN group of companies, so locating it at the heart of the UK manufacturing research and development activity, the AMP, was the natural choice. With world-class companies and research organisations in close proximity, the AMP is a perfect fit for Nikken to collaborate on challenging applications with global blue-chip organisations and technology leaders.

The first live machining demonstration carried out in August, was in the presence of the visiting President of NIKKEN Kosakusho Works Ltd. and colleagues from Japan and the USA. The trial, which was a comparative stability and slot cutting test in Titanium, yielded positive results for the Nikken X-Treme Chuck on a number of different cut speeds and depths.

Speaking about the move, Nikken Europe MD Tony Bowkett said "We have had a presence at the AMP since the very beginning and are founder members of the AMRC so locating our European Innovation Centre here made perfect sense. The strategy of supporting research and development in High Value Manufacturing is key to the continued success of UK Engineering and we are proud to be part of this world-leading community."

Rolls-Royce announces gearbox joint venture and Ethiopian Airlines success

Rolls-Royce and Liebherr-Aerospace are setting up a 50/50 joint venture to develop the capability and capacity to make the power gearbox for Rolls-Royce's new UltraFan™ engine.

UltraFan™ could be ready for service from 2025, and will offer at least 25 per cent improvement in fuel burn compared with the first generation of Rolls-Royce Trent engines.

The power gearbox will enable UltraFan™ to deliver power efficiently over a range of take-off thrusts for high-bypass ratio engines of the future. Each gearbox on the highest thrust engines will be able to handle the equivalent horsepower produced by more than 500 family cars.

Tony Wood, Rolls-Royce President – Aerospace said: "The UltraFan™ engine design includes a suite of new technologies to power next-generation aircraft. The power gearbox is an integral part of this new design, and we are delighted to be partnering with Liebherr on this highly efficient future power gearbox technology."

Rolls-Royce has significant experience of the use of power gearboxes, with four geared designs currently in production (AE2100, T56, LiftFan and Model 250) and with thousands of engines in service.

The majority of the design expertise of the new power gearbox will reside within Rolls-Royce Germany. Rolls-Royce has started building a new power gearbox test centre at its Dahlewitz site, south of Berlin, representing an investment of more than €80 million, partly funded by the Brandenburg government.

Ethiopian Airlines has decided to take Rolls-Royce Trent 1000 engines and long-term TotalCare® support worth $500 million to power six Boeing 787-8 Dreamliner aircrafts.

Rolls-Royce says the decision marks a significant vote of confidence in the Trent 1000, given that Ethiopian Airlines had previously selected another company's engines to power 13 Boeing 787 Dreamliners.

Tewolde Gebremariam, Ethiopian Airlines, chief executive officer, said:

"We are pleased that the Trent 1000 will power this latest round of aircraft. We have confidence that it will deliver outstanding lifetime fuel burn, performance and reliability."

Dominic Horwood, Rolls-Royce, chief customer officer - Civil Large Engines, said: "This is a significant selection by a valued customer that continues the Trent 1000 success story. We have real momentum in the marketplace - in the last five years the Trent 1000 has been selected in more than 60 per cent of engine competitions."

Ethiopian has ordered Trent XWB engines to power 12 Airbus A350 XWB aircraft and has three RB211-powered Boeing 757 aircraft in service.

Photo L to R: Josef Gropper, Managing Director & COO Production, Liebherr-Aerospace & Transportation Systems, Dr. Norbert Arndt, Executive Vice President - Structures & Transmissions, Rolls-Royce, Arndt Schoenemann, Managing Director, Liebherr-Aerospace Lindenberg GmbH, and Dr. Rainer Hönig, Managing Director, Rolls-Royce Germany

Korean business delegation ‘first’ for AMRC

Members of a South Korean business delegation have toured the AMRC as part of an initiative designed to boost trade and investment.

The delegation was the first, led by a representative of the South Korean government, to visit a UK region outside London.

Delegates held meetings with representatives of local government, business and academia in the AMRC Knowledge Transfer Centre, before visiting the Nuclear AMRC, where they signed Memorandums of Understanding with the University of Sheffield and the Sheffield City Region Local Enterprise Partnership.

They then toured the Factory of the Future and the Composite Centre.

Speaking during the visit, University of Sheffield Vice Chancellor, Professor Sir Keith Burnett, emphasised the links that already existed between the university and Korea and the importance of having a vibrant Korean community in the academic world.

Sir Keith said the university was eager to expand its relationship with Korean industry.

“We greatly admire the manufacturing prowess of Korea. It has done the most extraordinary and wonderful things across a whole range of activities,” said Sir Keith.

“We believe we have here something to offer to your Korean colleagues. We would love to be your partners in the next generation of products.”

Jounghwan Lee from the AMRC Composite Centre played a key role in helping to facilitate the visit.

Photo L-R: James Newman (Sheffield City Region Local Enterprise Partnership Chairman), University of Sheffield Pro Vice Chancellor Prof Richard Jones, Y S John, Korean delegation leader Jeonghwa Han and Joon Chung, Chairman of the Korea Venture Business Association, who signed the Memorandums of Understanding.

AMRC strengthens links with Korea following new agreement on collaboration

The University of Sheffield is to set up a branch of its Advanced Manufacturing Research Centre (AMRC) with Boeing in the Republic of Korea (South Korea).

The new Korean AMRC (KAMRC) is being established following the signing of a Memorandum of Understanding (MoU) by the University, the Korea Institute of Carbon Convergence Technology (KCTECH), Jeonju University and Jeonju City.

The agreement builds on an earlier MoU, signed in 2012 by the University, KCTECH and Jeonju City, which heralded the start of international collaboration between the organisations.

Since then several successful projects have been undertaken and KCTECH was officially recognised as an Associated Laboratory by the AMRC early this year.

One project led to researchers from the AMRC, KCTECH and the SsangYong Motor Company winning the JEC Asia Award for innovation in automotive applications for their work on developing a complex composite acoustic cover for a car engine bay that could be cured in an industrial microwave.

The new MoU will lead to further collaboration on research, support Korean suppliers to AMRC partners and promote educational cooperation on the joint development of manufacturing courses and student exchanges.

The KAMRC will be a wholly owned subsidiary of the University of Sheffield.

The MoU was signed during a visit to South Korea by AMRC executive dean, Prof Keith Ridgway, CBE; the head of the AMRC Composites Group, Richard Scaife, and Jounghwan Lee, who was involved in the research which led to the JEC Asia Award.

AMRC executive dean, Professor Keith Ridgway CBE, second left, pictured with representatives of the Korea Institute of Carbon Convergence Technology (KCTECH), Jeonju University and Jeonju City, after signing the Memorandum of Understanding that will lead to the University of Sheffield establishing a Korean AMRC.

Factory 2050 Update:
Pioneering data driven, digital factory nears completion as AMRC continues to expand

The AMRC's ground breaking Factory 2050 development is nearing completion.

Construction group Interserve completed the external cladding of the building in August and has been installing flooring and completing internal fitting out and finishing.

Fencing and street furniture is being installed around the development, designed to be one of the most advanced factories in the world, combining cutting edge manufacturing and assembly technologies.

Landscaping and paving is also underway, ahead of the handover, scheduled for the start of November.

Equipment will start being moved into the new building as soon as the keys are handed over and the majority of the kit should have been installed by April.

Robotics, autonomous vehicles and component tracking systems will be a key feature of Factory 2050's new, data driven, digital environment.

Factory 2050 has been designed to help advanced manufacturers respond to increasing demand for high levels of flexibility and will be home to the AMRC's Integrated Manufacturing Group (IMG).

The £43 million development will be the UK's first fully reconfigurable assembly and component manufacturing facility for collaborative research, with the capability of rapidly switching production between various high-value components and one-off parts.

Facilities will include advanced robotics, flexible automation, unmanned workspace, off-line programming in virtual environments linked to plug-and-play robotics, 3D printing from flexible automated systems, next generation man-machine interfaces, and new programming and training tools.

Sophisticated monitoring systems will generate large volumes of information, which will be used to develop technology that allows machine tools and processes to change the way they are working, maximising production rates and minimising tool wear, while maintaining quality.

The development will ensure that the UK's advanced manufacturing supply chain can tap into the expertise it needs to make the most of increasing requirements to make rapid changes to product design, as a result of ever-changing customer demands.

The new development's facilities will be at the heart of a £1.6 million research project that will take aerospace manufacturing technology into the construction industry, developing advanced, flexible manufacturing systems which be used by construction and engineering group Laing O'Rourke in a new factory manufacturing modular systems for new homes and other buildings.

Factory 2050 will be home to a project to explore future digital factory technologies for one of the world's largest independent producers of commercial aeroplane structures, Spirit AeroSystems.

Once it is operational, Factory 2050 will employ around 70 people and directly contribute almost £2 million to the local economy every year.

The glass walled factory is also intended to excite young people about the prospects of a career in 21st century engineering.

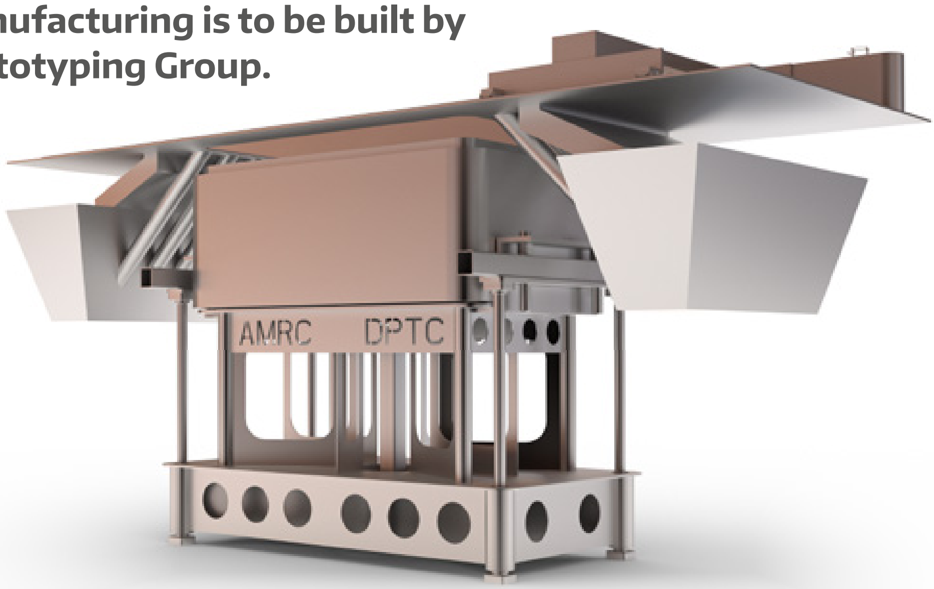
Factory 2050 is part funded by the European Regional Development Fund and the Higher Education Funding Council for England, each of which are contributing £10 million to the project.

The landmark building has been designed by Sheffield architects Bond Bryan and built by Interserve Construction.

3D printing

goes high speed and high volume

The world's first additive manufacturing (3D printing) machine that can make plastic parts as fast and as cheaply as traditional manufacturing is to be built by the AMRC Design and Prototyping Group.



The machine will build parts up to three times larger and 100 times faster than current comparable additive manufacturing (AM) machines, making it capable of challenging conventional injection moulding for high volume production.

The £1 million project – funded by the Engineering and Physical Sciences Research Council (EPSRC) – has the potential to transform both manufacture and distribution. Low cost, high volume additive manufacturing would enable parts to be made where they are needed, rather than produced centrally.

Professor Neil Hopkinson from the University of Sheffield's Faculty of Engineering says: "Additive manufacturing is already being used to make tens of thousands of products – such as iPhone covers – and ten years ago that volume was unthinkable. This machine will enable serious production of volumes over one million, which is currently inconceivable. I believe history will repeat itself and in ten years' time, producing volumes over a million using additive manufacturing will be commonplace."

The machine is based on a technology developed by Professor Hopkinson, who originally filed patents on the process as lead inventor at Loughborough University. The technology for high speed sintering (HSS) is being licensed to industrial machine manufacturers on a non-exclusive basis, with new machines being expected on the market from 2017/18.

The machine will initially be built in the University of Sheffield's Advanced Manufacturing Research Centre (AMRC) before installation in the university's centre for Advanced Additive Manufacturing (AdAM), of which Professor Hopkinson is Director.

Dr Andy Bell, from the AMRC's Design and Prototyping Group, said: "This machine will be built completely from scratch, drawing on all the skills and expertise of our design engineers. We have been involved in developing machines with commercial partners in the past, but this will be the biggest machine we have ever created."

The machine will use the HSS process which selectively fuses polymer powder layer by layer.

Instead of using lasers, HSS prints infra-red-absorbing ink onto a powder bed. Once a layer has been printed, it is exposed to infra-red light, which heats the powder covered by the ink, causing it to fuse, while the rest of the powder remains cool.

The new machine will be able to make parts up to $1m^3$ – the size of a washing machine – which is three times bigger than the capacity of existing machines. The speed will depend on the size of the product, but the team estimate that small components will be built at a rate of less than one second per part, allowing AM to compete with injection moulding for high volume manufacturing.

AM has advantages over injection moulding which makes the process more attractive, as Professor Hopkinson explains:

"With additive manufacturing you can make more complex parts and make each part unique," he says. "You can also make the parts where they are needed, which reduces transport costs. Additive manufacture also limits the risks involved. With injection moulding, you have to make tools, which is expensive and has to be done in advance. With AM, you miss out that stage, moving straight from design to manufacture."

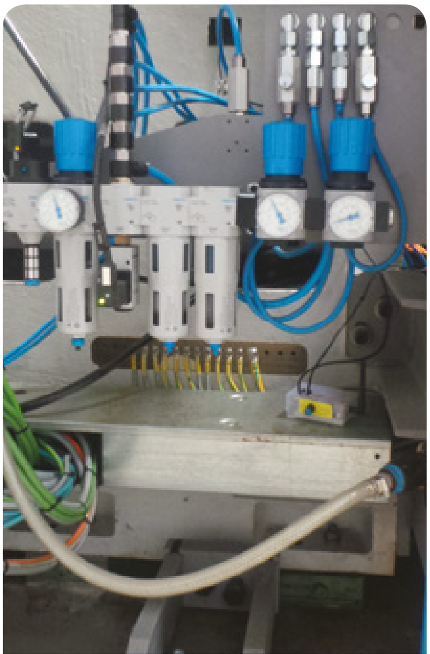
WILL BUILD PARTS UP TO
3XLARGER
100XFASTER

Low cost machine tool monitoring project gets the chemistry right for engineering leadership

An initiative that aims to develop engineering leaders of the future has led to a young chemical engineer developing a low cost way of monitoring the temperature of different parts of a machine tool.

Robin Hartley is studying Chemical Engineering at the University of Sheffield and has been working on the project at the AMRC as part of the Sheffield Engineering Leadership Academy (SELA) programme, run by the University of Sheffield.

Participants attend professional skills workshops, hear talks by influential engineering leaders and take part in two large, year-long group projects that run alongside their academic studies.



Hardware for Robin's wireless sensor unit in situ at the AMRC Factory of the Future shop floor

Robin secured his placement at the AMRC after hearing an SELA talk by a senior Rolls-Royce engineer about leadership and his role within the AMRC.

"At the end of this workshop, I was keen to follow up the opportunity and was lucky enough to find myself being interviewed the very next morning for a 10 week summer placement within the Process Technology Group (PTG) at the AMRC," said Robin.

Robin's placement is with PTG's Process Monitoring and Control operation, which studies measurement, computation and autonomous control within advanced manufacturing processes.

"My project is to design and develop the software and the hardware for a wireless sensor network which can provide a drop in solution for monitoring the temperature of multiple machine tools on the shop floor of the AMRC's Factory of the Future," he explains.

"My system uses the popular Arduino and Raspberry Pi platforms alongside inexpensive ZigBee radios which together provide a compact and low cost solution for wireless data acquisition."

Two of Robin's wireless units have recently been installed on CNC machine tools as a proof of concept system.

Each unit has multiple temperature sensors which record data from different locations such as the main spindle motor housing, the machine bed, the coolant fluid tank and the ambient workshop temperature.

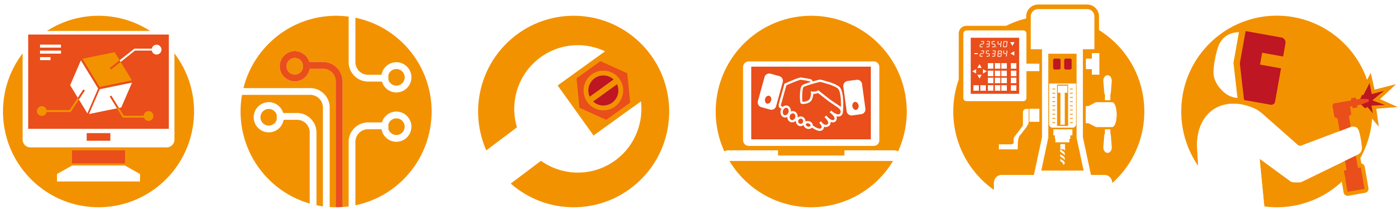
Robin's system could be further developed to work with a range of Arduino-compatible sensors allowing a range of different parameters to be wirelessly monitored and recorded. This data could then be used to help identify anomalies and improve manufacturing processes to ensure machines always work at optimum conditions.

Robin said: "As a Chemical Engineering student, I have found this placement very rewarding as it has enabled me to expand my knowledge of programming, wireless communication, electronics and process monitoring in a multidisciplinary engineering environment.

"This has been a great opportunity to apply my engineering skills in a new context, whilst taking on the responsibility for developing, delivering and presenting my project against a number of design criteria; on time and within budget."

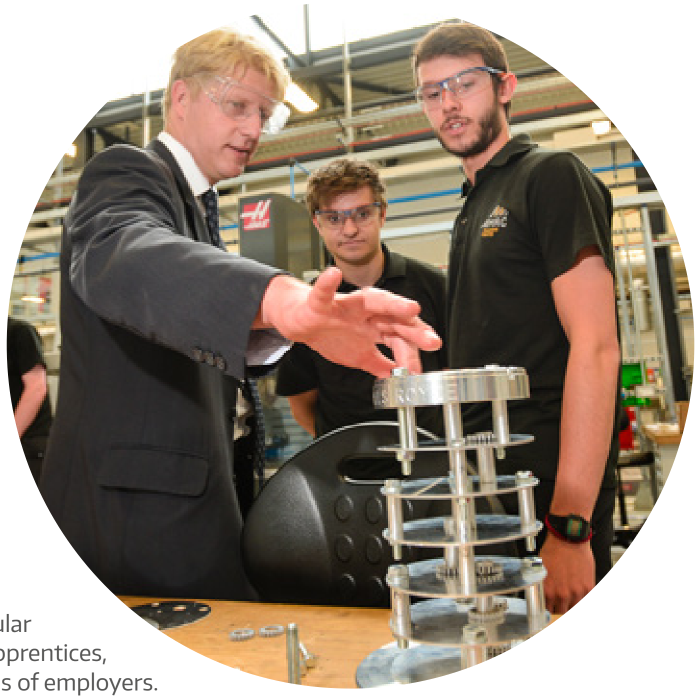
AMRC project manager Simon Hogg, who has been supervising Robin's placement, said: "Robin has been working alongside our own engineers and has managed to adapt his skill set to allow us to progress wireless data collection.

"We have adapted the scope of his project dynamically during his placement to fit it to the needs of multiple internal customers including manufacturing engineers and IT managers."



Minister unveils pioneering new route for apprentices to gain a university degree

The AMRC has unveiled a pioneering new education route that enables successful apprentices to study advanced vocational university degrees, as part of their apprenticeship training.



The University of Sheffield will become one of the first in higher education to offer quality advanced manufacturing Foundation, Undergraduate and Masters degrees using the apprenticeship model. Successful apprentices will have the opportunity to continue their studies up to Masters level.

The news was announced by Minister for Universities and Science, Jo Johnson, during a visit to the AMRC. Mr Johnson highlighted the key role the degree level apprenticeships will have in supporting innovation and boosting productivity.

The new educational pathway will be developed thanks to a £1.6 million HEFCE funding award. The award will give groups under-represented in higher education access to world class university education in an internationally leading translational research context, with simultaneous work-based training to create the next generation of engineers.

Jo Johnson said: "The new degree-level apprenticeship will provide a way for students to take their capabilities to advanced levels, and not only means brighter prospects for them, but provides a stronger talent pool for businesses."

The traditional route to becoming an Incorporated or Chartered Engineer is through GCSEs, A-levels, an academic BEng or MEng degree at university and then employment.

The new route will feature an innovative curriculum in advanced manufacturing to recognise the skills, experiences and particular learning styles of the apprentices, while meeting the needs of employers.

University of Sheffield Vice-Chancellor Professor Sir Keith Burnett said: "Universities have a key role to play in driving innovation, economic growth and creating jobs.

"I am delighted that Sheffield has worked closely with HEFCE and industry partners to respond to this challenge to develop the very highest quality apprenticeships. It also complements our significant investment in engineering teaching, including a state of the art £81 million engineering building on our main campus offering truly exceptional facilities for this vital area of teaching."

AMRC executive dean, Professor Keith Ridgway, CBE said: "The new pathway will be delivered with a curriculum which will provide academic rigour alongside practical skills and high quality employer-led training that is designed to meet business needs and create the professional, creative engineers of tomorrow.

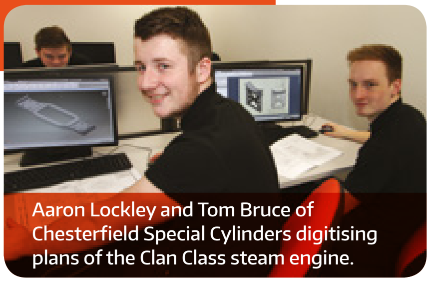
"The innovative new model of work-based learning is expected to attract different groups of students than traditional academic models, increasing diversity within cohorts and ultimately within the profession itself."

Professor Madeleine Atkins, chief executive of HEFCE added: "Technical education is part of the ladder of opportunity that needs to lead into higher education to ensure the country uses all its talents inclusively and that prosperity is spread.

"HEFCE is pleased to support the Sheffield project from our Catalyst Fund, addressing as it does our priorities to support the Productivity Plan, including links with Catapults, technical education and anchor role of universities."

Historic locomotive plans pose new challenge for AMRC apprentices

A project to build a steam locomotive fit for the 21st Century is getting a helping hand from apprentices at The University of Sheffield AMRC Training Centre.



Aaron Lockley and Tom Bruce of Chesterfield Special Cylinders digitising plans of the Clan Class steam engine.

British Railways built 10 of the locomotives in the 1950s and named them after Scottish clans. Plans to build 15 more and name the first five after Kentish warlords were abandoned due to steel shortages, followed by a switch from steam to diesel.

None of the 'Clan' Class locomotives survived, but the project team has microfilmed drawings for the next engine, which would have been the 1,000th Standard Class Steam Locomotive built by BR and was to be named 'Hengist', after a fifth century King of Kent.

If the team is to succeed, it needs to turn the 900 microfilmed drawings into modern CAD drawings.

"It's an ideal challenge for the AMRC Training Centre apprentices," said Phil Yates, a project engineer with the AMRC's Integrated Manufacturing Group, who heard about the 'Clan Project' from team member and near neighbour Geoff Turner.

"The original drawings could be massively complicated because they tried to get in as much detail as they could – fitting numerous separate parts onto each one.

"Taking the microfilmed drawings, constructing the parts in CAD, validating them and seeing how they fit together involves reading and interpreting the drawings and designing the parts – it's an essential skill the apprentices need."

CAD data is needed for the modern machine tools that will make the components and because the project team needs to comply with modern safety standards and wants to make Hengist more efficient.

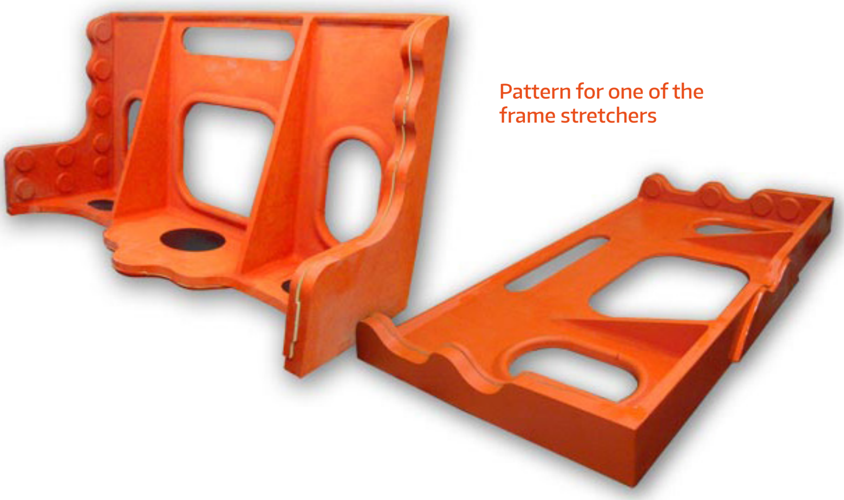
Enhancements will include dual circuit braking, which has to be shoehorned into space in the existing design and the best way to do that will be to use a Virtual Reality model generated from the CAD drawings.

Geoff Turner said: "We are delighted that the AMRC Training Centre apprentices are involved in the project, learning valuable engineering skills from reading engineering drawings, applying current draughting standards and applying modern manufacturing techniques in the process."

Between six and 10 apprentices will gain vital CAD skills by working on the project in the coming months and there is scope for AMRC Training Centre apprentices to work on other parts of the Clan Project, which is due to be completed in 2026.

For more information on the 'Clan Project', visit **www.theclanproject.org**

Further information about the AMRC Training Centre can be found at: **www.amrctraining.co.uk**



Pattern for one of the frame stretchers

State of the art skills harnessed by AMRC engineers to preserve Medieval history

Engineers from the AMRC are using digital measuring techniques to help archaeologists preserve historically important sites from the Middle Ages.

Metrology engineers Adam Wiles and Tom Hodgson have scanned one of only two medieval ossuaries left in the country for the Rothwell Charnel Chapel and Ossuary Project, run by the University of Sheffield's Department of Archaeology.

Ossuaries are vaults or chambers that contain human skeletal remains. It was thought that, in Medieval times, they were used to store bones removed from graves, which were then re-used. However, researchers now believe they were also centres of pilgrimage and commemoration.

Ossuaries were once commonplace in Christian European countries, but many English ones were destroyed or emptied during the 16th Century because of their link with pre-Reformation Catholic ideologies.

As a consequence there are only two examples in the UK which are slowly degrading, so scientists and archaeologists have a small window of opportunity to capture the data they hold.

The team have used a Leica ScanStation P20 laser radar to capture the interior of the ossuary based at Rothwell Holy Trinity Church in Northamptonshire. Spinning 360 degrees on a tripod, the radar captures single points on the surfaces it scans. It is moved to multiple locations to capture as many points as possible.

"The method is a very quick way of gathering a lot of data, which will be built up into a 3D image or virtual reality model of the inside of the ossuary," said Tom Hodgson.

"As ossuaries are usually within the catacombs of a church, the number of positions we had to move around the scanning equipment was limited. The challenge for the team was how we gathered data in a limited environment, without it hampering the quality of the final models."

Virtual reality models rendered by the AMRC are usually to create factory layout simulations, so companies can optimise their manufacturing processes. Using metrology to preserve data is a new venture for the AMRC.

The team hope that if the project has merit as a standard method for preserving sites of historical interest, that it will create an increasing demand for use of the technology outside the manufacturing sector.

Tom said: "The metrology data we produce will be a crucial element to the Rothwell Charnel Chapel and Ossuary Project. As the site degrades over time they may want to limit access to the general public to help preserve the artefacts."

Doctoral researcher, Jennifer Crangle from the Department of Archaeology and the Rothwell Charnel Chapel and Ossuary Project team said preserving a record of the data in this way will be useful for decades to come:

"As the stacks of bones will continue to degrade, the mass of the bones in future years can be compared to the scanning record, allowing us to document any changes over time.

"Rendering the data into a virtual reality model creates a permanent record of a unique site, allowing researchers and visitors to see the entirety of the exact crypt structure, as it has never been seen before."

Tom Hodgson operating the Leica ScanStation P20 laser radar inside the Rothwell Holy Trinity Church Ossuary.

New AMRC Catapult Fellowship to help companies maintain **accuracy without losing production time**

Dr Andrew Longstaff

New research to help manufacturers cut the production time lost by checking and setting up machine tools has been launched following the award of a prestigious four year EPSRC High Value Manufacturing Catapult Fellowship.

Dr Andrew Longstaff, a principal enterprise fellow from the Centre for Precision Technologies at the University of Huddersfield, will work on the project with the University of Sheffield AMRC with Boeing.

Dr Longstaff's research expertise is in the accuracy of machine tools, how errors build up over time and how that is affected by factors like temperature, machine movement and changes in loading conditions. He is a senior researcher in the globally-respected EPSRC Centre for Innovative Manufacturing in Advanced Metrology, based at the Centre for Precision Technologies.

Dr Longstaff said: "I'm delighted to receive this prestigious fellowship, which will not only help companies to be more productive but will also help them to correctly diagnose what is causing problems if they arise.

"Reducing the time you take to calibrate a machine tool is about having a structured approach to the more complicated and time consuming elements, supported by quick checks. I will be looking at what people need to measure, how they should measure it and how often they measure it.

"The results of the research will be spread among the wider manufacturing community through Catapult, enabling companies to reduce the time they take to calibrate machine tools and giving them more confidence that they will produce components accurately."

Dr Longstaff has previously worked with the AMRC on a successful project to reduce the time it takes to manufacture safety critical aero engine components.

While AMRC researchers succeeded in reducing machining times from days to hours, he focused on techniques for calibrating the machine tools – an essential process to keep them running accurately, which originally took them out of production for days, but can now be carried out in a single shift or less.

Dr Longstaff will also be working with AMRC's Process Monitoring and Control Group. The group's core disciplines include in-process inspection, adaptive machining and condition monitoring. By combining these disciplines with rapid machine tool calibration, industry can have confidence that processes developed at the AMRC are robust and transferable to production sites, ensuring accuracy and repeatability of the process and avoiding unnecessary equipment down time.

AMRC researchers succeeded in reducing machining times **from days to hours**

CATAPULT
High Value Manufacturing

CUTTING TOOL MANUFACTURER OSG JOINS AMRC AS TIER ONE PARTNER

Cutting tool manufacturer OSG has joined the AMRC as a tier one partner.

OSG Corporation is a leading manufacturer and supplier of a comprehensive range of high value-added cutting tools, rolling dies and gauges, which has been expanding its global presence.

AMRC commercial director Adrian Allen OBE said: "We are delighted to have OSG as a tier one member.

"OSG has already been involved in AMRC projects related to titanium pocket milling and the trimming and drilling of Carbon Fibre Reinforced Plastic (CFRP).

"We look forward to further developing this relationship."

OSG supplies tools and develops processing methods optimised for the individual needs of manufacturers in sectors ranging from automotive and aerospace to mould and die making.

OSG was founded by Hideo Osawa in 1938 in Tokyo as the Osawa Screw Grinding Company and has grown into a corporation with production, sales and technical support network spanning 29 countries, including the US and Canada, China, Korea and Brazil as well as several countries in Europe.

OSG expanded to the UK 16 years ago, acquiring the family-run business Norman Taps and Dies, which had for many years manufactured specialist taps and dies and sourced a range of products from OSG and is now known as OSG UK.

"we are delighted to have OSG as a tier one member"

Adrian Allen OBE,
AMRC commercial director

NEW PARTNERSHIP WITH METROLOGY COMPANY TO BOOST MACHINING EFFICIENCIES

Metrology software products (MSP) has become a tier one Partner at the AMRC.

MSP has decades of metrology, calibration and machining experience, which it uses to develop world class precision software and part manufacturing solutions for machine tools.

Its award-winning software is designed to harness the full potential of probe technology, enabling manufacturers to accurately identify and rectify production problems.

MSP's software products have two main benefits to help companies make perfect parts. They enable companies to automatically set components up on a machine tool ready for machining operations, whilst ensuring they are correctly fixtured to within microns.

Secondly, they benchmark these machine tools to ensure their geometric performance means the machined parts will meet the necessary tolerance requirements.

MSP's expertise has already been used in a number of AMRC projects in support of research into five-axis probing techniques for high value manufacturing.

It will now be used in ever more demanding engineering projects designed to help the British aerospace sector increase its international competitiveness and will be made available to other AMRC partners and groups to help them meet the challenges of complex engineering projects.

MSP technical director, Peter Hammond, said: "We are honoured to become Tier one members of the AMRC. Our financial and technical investment serves to demonstrate our commitment to the evolution of high value manufacturing and the challenges facing the industry today and in the future.

"MSP welcome the opportunity to play a key role in the future development of complex engineering, it is a privilege for our expertise to be recognised as making a difference in the aerospace industry."

AMRC commercial director Adrian Allen OBE said: "We are delighted to have MSP as a tier one member. The research AMRC will undertake with MSP, installing and testing their software on our machining tools, will help us benchmark machine performance. This knowledge will help our members achieve increased efficiencies when machining."

"our commitment to the evolution of high value manufacturing"

Peter Hammond, MSP technical director

INDUSTRY 4.0

Targeted investment could put Britain in the driving seat for the next Industrial Revolution

Alan Norbury, Siemens UK industrial chief technical officer

Britain could be back in manufacturing's driving seat and spearheading a fourth industrial revolution with the right Government investment, according to Alan Norbury, Siemens UK industrial chief technical officer.

Mr Norbury was delivering the opening address at a half day seminar on the implications of 'Industry 4.0' for manufacturers.

He told delegates, pressures to shorten the innovation cycle, while increasing flexibility to open the way for 'mass customisation', were combining with new technologies that generate masses of data to create the next industrial revolution.

Britain had been at the forefront of the first industrial revolution, when water and steam power had been harnessed to drive machinery.

The second industrial revolution arrived with the advent of mass production and the third had come with the development of Information Technology and devices like Programmable Logic Controllers.

The fourth industrial revolution - Industry 4.0 - was being driven by the creation of 'cyber physical systems' and the 'Internet of Things,' where "the virtual world meets the real world."

Industry 4.0 would extend commercial models that were already making the most of data and had resulted in the move from bookstore to e-book and record store to streaming, Mr Norbury predicted.

Individualised mass production was already a feature of the automotive sector, with customers selecting the features they wanted for their new car, which would then be built on a production line, alongside similar models with different combinations of features.

The clothing sector would be the next, offering customised, mass produced garments, and other sectors would follow.

The development of cyber physical systems would enable products to be designed and developed exclusively in the virtual world, without the need to make prototypes and there would be every chance that when a physical product was made, it would be right first time.

Machines would become 'self-aware;' able to self-optimise and self-heal, said Mr Norbury. Capabilities might include being able to analyse the vibration, temperature and harmonics of drive motors, so that a machine could predict a potential failure and then either adjust its speed to prolong the motor's life or arrange for maintenance.

"The technology is there now and will develop over the years," said Mr Norbury.

Machines would also be capable of feeding data back to virtual world models to see whether similar, but different, products might be made on the same production line.

RFID achieves its early promise
to become another component in implementing Industry 4.0

Adam Bowes, technical sales manager, Fairfield

Advances in sensor technology are helping companies to add value to their products and compete successfully against low cost producers in demanding markets.

Adam Bowes, technical sales manager with systems integrator Fairfield, explained how advances in battery-less RFID (radio-frequency identification) meant the technology had caught up with expectations, while costs had come down, creating new potential for realising Industry 4.0 ambitions.

Mr Bowes cited the example of a client making a range of conveyor belts for the potash, coal and iron ore mining industries.

The belts are 300 metres long, weigh up to 40 tonnes and often spend years in storage, either at the manufacturer or on top of a mine.

"There were hundreds of belts in the factory and they all looked identical. It may appear difficult to lose a 40 tonne belt, but among 60,000 tonnes of conveyors, they could lose several of them on site," said Mr Bowes.

Deciding which type of belt to make and when to replace them in a mine was also a problem.

"They used to manufacture the belts according to what they thought the mining customers would need and would have to inspect the belts, which meant flying an engineer out to do it manually, which was an expensive process," Mr Bowes added.

With Fairfield's help, the company began embedding RFID sensors every 100 metres in the belts' woven PVC carcass and moved away from its old paper-based systems.

Now, manufacturing equipment, including an automatic crane, reads the RFID tag on the carcass, calibrates itself and starts producing the belt.

Belts in storage at the plant or the customer's mine can be tracked down using hand held scanners and software linked to scanners in the underground conveyors calculates when belts need replacing, which means there is a full audit trail from manufacture through to decommissioning.

From struggling to remain competitive, the conveyor belt manufacturer had been able to improve its forward planning, reduce staffing costs, increase profitability and offer mining clients added value which meant its conveyors were being chosen ahead of cheaper ones made by competitors.

RFID was now being used to locate trailers up to 40 metres away in a haulage company's compound, while tags half the size of a grain of rice were being used to track surgical instruments a metre away.

"There are huge applications in healthcare," said Adam Bowes.

"Hospitals will buy five times more than they need of a particular product because they don't know where it is going to be at any one time. We do a lot of asset tagging – MRI scanners, defibrillators..."

Skills shortages and connectivity pose challenge for Industry 4.0 adopters

Alan Norbury, Siemens

Companies seeking to reap the benefits of the latest Industrial Revolution face two major hurdles, according to Alan Norbury, from Siemens - skill shortages and communications infrastructure.

One of the big questions still to be answered was how factories and the supply chain could be connected digitally, Mr Norbury told the Industry 4.0 conference.

"Sensor technology is becoming more intelligent, with built in Ethernet capabilities and computing power that can generate 'Big Data,' but how do you manage that and make it useful for your business?" asked Mr Norbury.

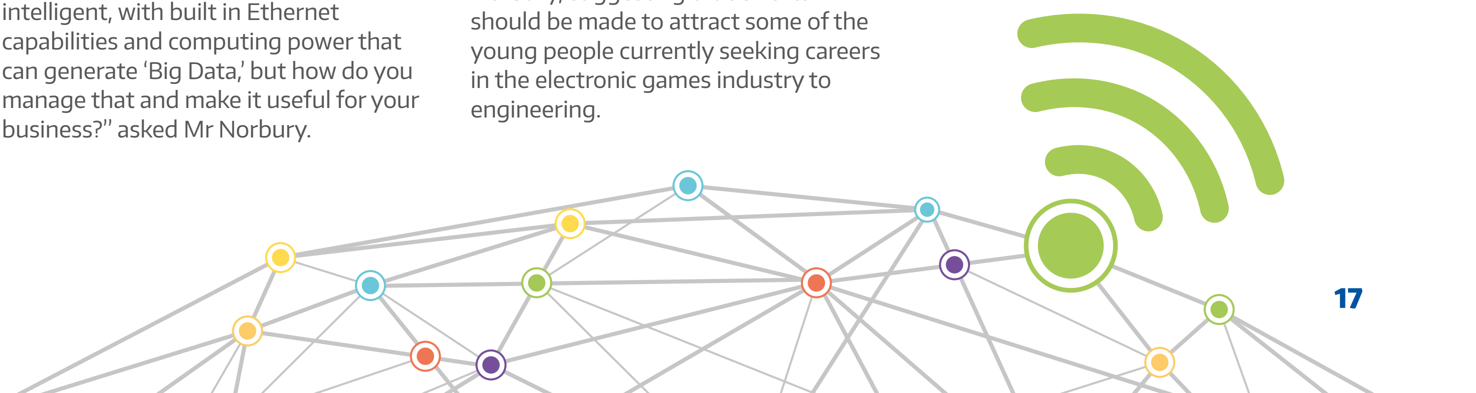
"Only 30 per cent of manufacturers use the Ethernet in the manufacturing environment, so how does the remaining 70 per cent become part of the Internet of Things? It's a massive investment."

Investment was needed in infrastructure, the development of an industrial Ethernet and appropriate skills.

"Engineers of the future will probably spend more time in the virtual world than in the real world, predicted Mr Norbury, suggesting that efforts should be made to attract some of the young people currently seeking careers in the electronic games industry to engineering.

Germany was targeting a 30 per cent increase in productivity as a result of the development of Industry 4.0. If Britain used robotic technologies that were available today to the same extent as the leaders in automation, it could increase productivity by 22 per cent and employment by seven per cent.

"I truly believe that, with the right government investment, Britain could be back in the driving seat of the fourth industrial revolution," said Mr Norbury.



INDUSTRY 4.0

Engineering must speak a common digital language to reap the benefits of benefits of Industry 4.0

Dominic Bramley, IBM

Russ McKay, IBM

Interoperability, open protocols and open standards are the key to the real time data collection, storage and analysis that will underpin the successful development of the Internet of Things for manufacturing, Dominic Bramley from IBM told the Industry 4.0 seminar.

"Industry 4.0 is the Internet of Things for manufacturing," said Mr Bramley.

"The real thing is in the analysis - real time analysis - and interoperability is a key point. The drive to open protocols and open standards, where possible, is really, really going to help.

"The Internet of Things is a big data challenge. Masses and masses of data have to be correlated in real time."

Creating a common language to describe a digital engineering requirement was important and international aerospace and automotive companies were widely adopting that approach, but the difficulty was getting it adopted by the supply chain.

IBM colleague Russ McKay outlined how car manufacturers, airport operators and facilities managers are among those already reaping the benefits of Industry 4.0 and the related Internet of Things.

When problems with the quality of the paint finish on some new cars began plaguing one manufacturer, dried paint dropping off extractor fans was found to be to blame, IBM's Russ McKay, told delegates to the Industry 4.0 seminar.

The solution was to fix an accelerometer to the fan in the electrostatic paint shop and clean the fan once the increase in vibration, caused by dry paint, reached a pre-determined level.

When an airport operator faced paying hefty compensation to low cost airlines that missed slots because air bridges taking passengers to and from the aircraft to the terminal building were failing and couldn't be repaired in time, it solved its problems with the help of the Internet of Things.

In the past, every time someone pressed the big red button to halt the air bridge when it broke down, they also had to telephone the airport's maintenance division, which would investigate the problem and repair the bridge.

Now, thanks to a couple of internet enabled sensors, pushing the big red button automatically triggers an alarm and transmits data about the failure to the maintenance division.

What was even better was the airport discovered that sloppy operation of the air bridge by the low cost airlines' employees was to blame and it was able to charge them for the damage that was being done.

Self-registering, secure sensors were now really inexpensive and easy to install, said Russ McKay, citing one example where 1,000 sensors had been installed in a building in under four hours and connected to a building information management system providing detailed analytics of building use and energy consumption.

> **"Industry 4.0 is the Internet of Things for manufacturing"**
>
> Dominic Bramley, IBM

Digital workflows
to boost efficiency, compliance and collaborative working

Sean Hennelly, vice president for products, Intoware

Companies aiming to digitise their work flows by introducing wearable technology are being urged to take a step back and consider mobile technology first.

The advice came from Sean Hennelly, vice president for products at Intoware, the leading developer of software products for embedded and wearable technologies and creators of WorkfloPlus, the digital work instructions system that works on wearable, mobile and desktop platforms.

"Virtually every single company we work with is using paper-based systems, not 'rubberised computers' and mobile phones, so we get customers to take a step back and look at mobile technology first," Mr Hennelly told the Industry 4.0 seminar.

Businesses usually had some digital technology, but not on the shop floor, which relied on information that had been printed off.

Engineers wasted hours inputting data at a desk and when they were on a job they had to rely on manuals that might have to be printed off once a month and were difficult to use in the field.

Hand overs between engineers were made more difficult by paper-based systems and it was also difficult to establish an audit trail or ensure compliance when procedures changed.

Going digital increased efficiency, made it easier to ensure updated procedures were rolled out, helped to ensure compliance, gave engineers in the field access to digital libraries of on the job information, allowed a number of employees to carry out different tasks linked to the same job simultaneously and made it easier to hand a job over.

Companies could check staff were following procedures and not simply "tapping through" the steps on a computer by getting them to enter sensor readings and take pictures or by recording the time between steps being completed.

The data could also be used to collect information on how the most efficient staff completed a task and get feedback from staff in the field.

Last but not least, moving from a paper-based to a digital workflow also opened the way to accessing expert assistance in remote or risky locations.

When one of Intoware's clients in the oil and gas sector was concerned about potential security risks to staff if their advice was needed on site in the Middle East, Intoware came up with a solution involving Motorola's HC1 headset computer.

The HC1 allowed an expert on the other side of the world to have the same hands on view as local engineers.

"The expert can share your view, they can speak to you and your hands are free to do the job. It's like having the expert on site with you," said Sean Hennelly.

Motorola HC1 headset computer

Carl Andrews, IPI Solutions

Data collection from Industry 4.0 could reduce risk and speed approvals processes

Increased facilities for data collection and analysis at the heart of the latest industrial revolution could help companies to meet pressure from top tier customers to reduce lead times.

Carl Andrews, business development director at business process improvement software and services specialist IPI Solutions, told Industry 4.0 seminar delegates that most top tier companies in the aerospace, automotive, oil and gas, medical and nuclear industries required either First Article Inspection Reports (FAIR) or had a Production Part Approval Process (PPAP).

The ability to integrate digital manufacturing data and manage the workflow required to achieve either FAIR or PPAP would not only speed the process, but would also help companies to identify risk earlier and avoid it.

INTERNATIONAL ACADEMY RESEARCHERS MEET AT THE AMRC

Research affiliates from The International Academy for Production Engineering (CIRP), travelled to the AMRC to exchange information on some of the latest developments in their fields.

CIRP is the world leading organisation in production engineering research and is at the forefront of design, optimisation, control and management of processes, machines and systems.

The Academy has restricted membership based on demonstrated excellence in research and has some 600 academic and industrial members from 50 industrialised countries.

It aims to promote research and development among its members from academia and industry to contribute to the global economic growth and well-being of society.

Delegates were welcomed by Dr Sam Turner, the AMRC's chief technology officer, head of its Process Technology Group and a corporate member of CIRP, representing the High Value Manufacturing Catapult.

Dr Turner outlined the history and development of the AMRC from a handful of researchers within the University of Sheffield's Faculty of Engineering to an organisation with 450 staff and a further 50 doctoral students, that had an emphasis on "innovation, inspiration and impact" and was continuing to expand.

Sam Turner, chief technology officer, AMRC with Boeing

Seminar venue: The AMRC's Knowledge Transfer Centre

New focus on understanding the properties of powders used in additive manufacturing

Candice Majewski,
AdAM Centre,
Department of
Mechanical Engineering,
University of Sheffield

Selecting materials used in additive manufacturing (AM) by trial and error could become a thing of the past thanks to research underway at the centre for Advanced Additive Manufacturing (AdAM) at the University of Sheffield.

Dr Candice Majewski, from the AdAM Centre, told the CIRP Research Affiliate Workshop that there was now a major focus on understanding the materials used in special polymer processes like laser and high speed sintering.

Dr Majewski said that until recently materials suppliers had not been interested in testing or developing materials for AM, as it was largely focused on prototyping or small scale production.

However, an increasing number of larger companies had started to take AM seriously as a means of manufacturing and potential levels of business means larger materials suppliers are seeing the benefits that a greater understanding of the materials being used in AM could provide to accelerate their growth into this area.

Dr Majewski said the focus was currently on understanding the science behind existing materials rather than developing new ones.

"We are working with various companies, including material manufacturers who want to understand the science.

"It is possible that, in time, new materials will be developed specifically for particular processes, but we are fairly sure that most large manufacturers have materials that are useable," she added.

Temperature-related properties of powders, such as having a large super cooling window, sharp melt point, stable sintering region and degradation temperature well away from the melting temperature were all very important.

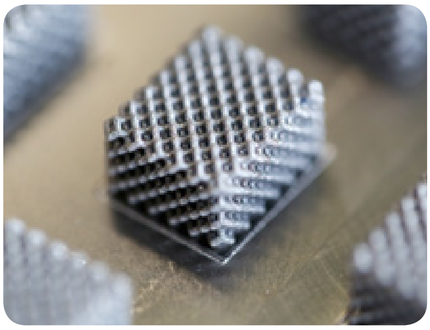
Materials with a high molecular weight could be too viscous and too difficult to melt, whilst materials with a low molecular weight could be too runny to ensure products were accurately defined.

Microstructure, mechanical properties and differences in particle size were also important factors, particularly since large particles might not fully melt.

Understanding the effects of these factors and their interactions will be crucial to expanding the range of materials available for these processes.

Researchers are also studying the way design can influence the capabilities of AM materials, said Dr Majewski, citing how laser sintering of standard polymers had been used to make a protective vest which could meet the Home Office standard for the lowest level of stab resistance.

They are also examining consumer perceptions of the quality of parts produced by different AM technologies.



Standard design rules and process planning are a must for additive manufacturing

Dr Wessel Wits, Faculty of Engineering Technology, University of Twente

Industry standard design rules and process planning are needed for additive manufacturing (AM) to gain industry acceptance, Dr Wessel Wits from the Faculty of Engineering Technology at University of Twente in the Netherlands, told delegates to the CIRP Research Affiliate Workshop.

Dr Wits said that AM was opening up new applications and manufacturing options, but lacked industrial acceptance as there is no standard knowledge base governing the design and manufacturing processes.

"Forces such as stress and thermal gradients affect AM processes; it's how we predict processes that is important, as it can change the way we design and manufacture support structures."

Computer aided synthesis of equations and parameters help designers refine the parameters for the processes and optimise quality of parts produced; but it is an area that hasn't been looked at in much depth by machine developers or designers.

He suggested those working in AM look at the shape of faults to identify what went wrong in a process, the in-plane process and different ways of producing layers; allowing designers to optimise designs and reduce the amount of supporting material needed to manufacture parts.

Wessel said: "By process planning and measuring the effects such as stress and deformation on parts, designers will be able to improve and stop negative impacts on the manufacturing processes."

"There aren't many design and support tools for AM at the moment and process behaviour is complex, we need more efficient modelling – for instance a database so we can optimise computer aided design and manufacturing processes to lead industrial acceptance of AM."

"By building a knowledge base of design rules for designers of the future, we will be able to take advantage of new options available to manufacturers."

Collaboration is the key
to meeting challenges faced in aerospace, research affiliates told

Dr Jamie McGourlay, Rolls-Royce partnership manager at the AMRC with Boeing

Aircraft manufacturers face significant challenges as they seek to introduce new materials and manufacturing techniques that will enable them to meet tough new targets to reduce noise, fuel consumption and emissions.

Jamie McGourlay, Rolls-Royce partnership manager at the AMRC, told the CIRP Research Affiliate Workshop aircraft manufacturers had achieved a fourfold reduction in noise since the 1950s.

Over the same period, there had also been a 70 per cent reduction in fuel consumption, despite a 4.25 per cent growth in the number of kilometres flown by airline passengers each year.

Now, aircraft manufacturers were aiming to reduce fuel consumption, CO_2 emissions and perceived external noise by 50 per cent, while reducing NOx emissions by 80 per cent.

To achieve that, manufacturers would have to challenge the way they behaved and the way they engaged and interacted with people, said Dr McGourlay, delivering the keynote address to the CIRP Workshop, held in the AMRC's Knowledge Transfer Centre.

Using in-house expertise to make incremental improvements behind closed doors, slowly pushing processes forward and avoiding the risk of failure was no longer an acceptable strategy.

Companies had to "maximise their opportunities and deliver world class solutions by forming alliances and sharing knowledge," said Dr McGourlay.

"Looking 10, 15, 20 years down the line, everything is going to change; materials and the way we use those materials is going to change."

Rolls-Royce's latest generation of nickel alloys for aero engines has taken 20 years to develop, test and introduce into service. The next generation of materials, capable of withstanding temperatures that are 50c to 100c higher would have to be introduced in less than half that time.

At the same time, manufacturers would have to adapt to new, knowledge-based manufacturing technologies and the challenge of 'Big Data' – the massive amounts of information generated by machines and IT systems.

"We currently exploit only a small fraction of the data available from a manufacturing system," said Dr McGourlay.

"How do we get our hands on that missing data, turn it into information, turn information into knowledge and turn knowledge into real opportunities?"

Jamie McGourlay emphasised the way that centres like the AMRC could bridge the gap between early stage developments at universities and industrial production.

He cited, as an example, a project involving Rolls-Royce and the AMRC on high performance disc machining, which doubled productivity, reduced the number of operations by 40 per cent and improved quality, leading to major investment in new UK manufacturing capability.

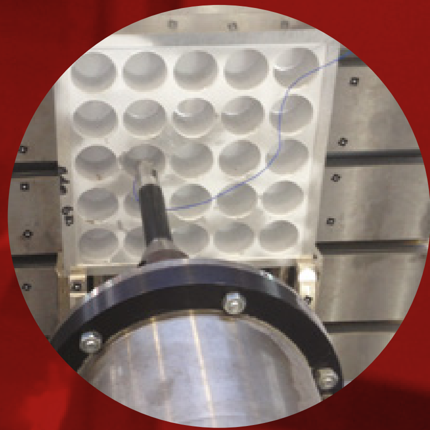
"The AMRC has catalysed all this growth and represents one of the best examples in the UK, if not Europe, of how to address the challenges we face," said Dr McGourlay.

"Having become members of the AMRC, we have gone on to support the creation of many others, modelled on the AMRC."

The Rolls-Royce UltraFan™ engine uses a broader application of innovative high-temperature materials.

Image: Rolls-Royce.

New techniques could make hexapod robots a viable alternative for milling applications



Hexapod machining trials at the Nuclear AMRC

Hexapod robots could offer a flexible alternative to CNC machines when it comes to machining large scale parts, thanks to research being carried out at the Nuclear Advanced Manufacturing Research Centre (Nuclear AMRC).

Dr Taner Tunc, research associate, Nuclear AMRC

The delegates heard that making large scale parts on CNC machines can be difficult and expensive, whereas using hexapod robots allows for a greater degree of flexibility and portability.

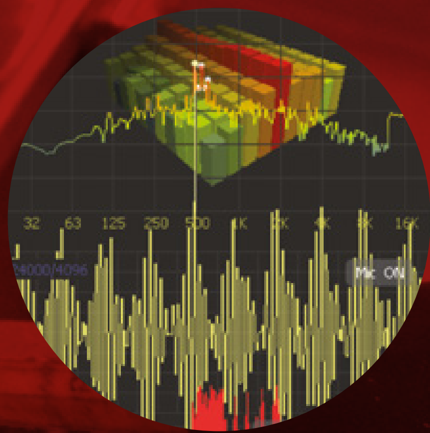
However, using robots can result in a loss of accuracy, says Nuclear AMRC Research Associate, Dr Taner Tunc, who has been assessing the accuracy of using hexapod robots for milling applications when machining large scale parts; where the robot is controlled by a robot controller rather than a CNC control as in machine tools.

Dr Tunc told workshop delegates that if a hexapod robot is unable to reach the programmed feed rate when machining circular parts, it can fluctuate and become unstable, causing unpredictable cutting forces, uneven loading and deflections and hindering chip formation.

Dr Tunc said: "Machining large scale parts using linear or circular interpolation makes a big difference to attainable feed rates and accuracy. Programming by linear interpolation is more common, but using circular interpolation to machine equal segments of circular parts made a big difference to feed rate and toolpath accuracy."

Dr Tunc said it was possible to reach higher feed rates and reach them sooner using circular interpolation, improving toolpath accuracy and the quality of parts.

He also emphasised that designing the feed drives and robot controls to meet the requirements of machining applications would substantially increase the accuracy of robotic machining.



Sound data during a cutting test in robotic milling

> **"using hexapod robots allows for a greater degree of flexibility and portability"**

The legs of a hexapod robot offer a greater degree of manoeuvrability when machining large components

COLD SPRAY TECHNOLOGY OFFERS OPTIONS FOR DIAMOND COATING LARGER COMPONENTS

Dr Rocco Lupoi, Assistant Professor, Mechanical & Manufacturing Engineering Department Trinity College, Dublin

New techniques could help to overcome limits on the size of components that can be coated by diamond-based materials, attendees at the CIRP Research Affiliate Workshop heard.

Rocco Lupoi, Assistant Professor within the Mechanical & Manufacturing Engineering Department Trinity College, Dublin, and colleagues have been investigating using a cold spraying process as an alternative to conventional technologies for the deposition of diamond.

Dr Lupoi said both diamond-PVD (physical vapour deposition) and CVD (chemical vapour deposition) are strong industrial processes, but have to be carried out under vacuum, so the components coated can only be small in size.

The cold spray process operates in normal atmosphere and uses supersonic nozzles fed by high pressure gases.

When material is fired at the surface it bonds really quickly, typically a thousand times faster than using processes like selective laser melting or sintering (SLM and SLS), enabling important capabilities in the field of additive manufacturing.

However, cold spraying brittle materials like diamond or ceramics is very difficult and typically requires the brittle material to be mixed with a ductile phase, for example cobalt or aluminium.

Dr Lupoi and his colleagues have been investigating a new strategy which involves electroplating the diamond with a thin layer of copper and nickel, instead of pre-mixing before being sprayed.

Using this strategy, they were able to deposit the diamond on an aluminium substrate at a rate of 1.8kg an hour, with a particle speed from the nozzle reaching 700m/s.

X-Ray diffraction analysis showed that none of the diamond was turned to graphite, as can happen in some extreme conditions. The copper and nickel acted as bonding agents and the coating was nearly 60 per cent diamond by volume. The proportions in the feedstock were transferred to the coating without changes.

Adhesion was stronger than expected; further work is now planned on the process to characterise the achieved deposits.

RESEARCHERS EXPLORE NEW TECHNIQUES FOR IMPROVING QUALITY AND MATERIAL REMOVAL RATES

Dr Erdem Ozturk, technology fellow, AMRC with Boeing, Process Technology Group

Improving surface quality through parallel machining and intelligent fixturing are among the techniques being investigated by CIRP research affiliates.

Increased removal rates and improved vibration control are among the potential benefits offered by parallel – or simultaneous – machining, the technique of using two cutting tools on opposite sides of the same workpiece at the same time.

Dr Erdem Ozturk from the AMRC outlined a series of research initiatives to develop models for parallel machining and demonstrate how varying spindle speeds, depth of cut, the number of flutes and the lag angle for each cutting tool on either side of a workpiece could improve production rates and quality by reducing chatter.

New research, funded by a European Union Horizon 2020 grant, aimed to develop an improved simulation platform over the next three years that would be able to take account of control errors and spindle non-linearity.

Future work could examine the potential for overcoming current limitations on machine design and develop technology to enable robots to undertake parallel machining.

A project to simulate intelligent fixtures that counteract the way workpieces vibrate during NC machining could help to improve the surface quality of finished components.

Professor Petra Kersting outlined the EU-backed research project Intefix involving the TU Dortmund University and 32 partners from six different countries.

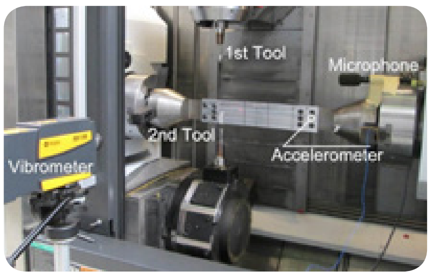
Researchers have developed their own system for simulating a fixture that would itself vibrate in such a way as to counteract vibrations caused by NC milling or grinding a thin walled component, like an impeller.

Their work will enable them to predict the surface topographies that can be machined using different processes and the next stage of their research will involve simulating an intelligent fixture for more complex workpieces.

Meanwhile, a project to simulate the gear hobbing process, using commercial CAD software could lead to means of calculating the stress on tools and modelling tool errors and vibration.

Current simulation model results include 3D gear and chip geometry as well as the cutting forces.

Dr Nikolaos Tapoglou, from Cranfield University, said that, at present, the simulation known as Hob3D, only works for solid tools, but there are hopes that tools with inserted cutters could be simulated in the future.



Parallel machining setup at the AMRC

STRUCTURED LANGUAGE OFFERS ROUTE TO EASIER PERFORMANCE ASSESSMENT

Dr Antonio Maffei, Department of Production Engineering, KTH Royal Institute of Technology

Dr Antonio Maffei from the Department of Production Engineering at Stockholm's KTH Royal Institute of Technology presented his framework for designing and evaluating higher educational engineering courses.

Dr Maffei's focus was on constructively aligning the use of language throughout courses in academic and practical teaching, allowing course providers to have accountable performance goals and students to verbalise educational targets, improving student engagement.

Antonio said it was important to consider the learning experience of the student, as helping students engage fosters a better understanding of the structure of course information.

"Structuring the language used throughout courses means educators can easily interrogate performance data attained by courses, making assessment easier," he added

He would like to see a pro-forma for designing educational courses and planned to expand his research to include other faculties and colleges.

KTH Royal Institute of Technology. Image: KTH Royal Institute of Technology

> helping students engage fosters a better understanding of the structure of course information
>
> Dr Antonio Maffei

NOVEL SENSOR IMPROVES UNDERSTANDING OF DAMAGE CAUSED TO COMPOSITES DURING MACHINING

Dr Kevin Kerrigan, machining technology lead, AMRC Composite Centre

Newly developed temperature sensors that can be integrated into tools to transmit data wirelessly are helping to improve understanding of the damage that can be done to composite materials during machining.

AMRC Composite Centre Machining Technology Lead, Dr Kevin Kerrigan told the CIRP Research Affiliate Workshop about the project to monitor machining damage during milling by measuring thermal energy.

The novel wireless integrated thermocouple sensor was used for low-temperature on-spindle machining applications in the peripheral milling of Carbon Fibre Reinforced Plastic (CFRP).

The sensor transmitted the characteristics of the thermal behaviour of the tool, during milling associated with the CFRP edge trimming process, to a data acquisition system.

Dr Kerrigan told delegates that investigations into the data indicated a general trend throughout all combinations of cutting parameters, in which an initial spike in thermal energy was followed by an exponential decay, until a constant heat flux value was reached for the remainder of cutting.

"Analysis of the data indicates that the axial location of the cutting interface on the tool has a minor effect on the milling process causing thermal degradation of the matrix material when using the tool tip.

"This is in contrast to the effect of feed rate, which causes significant changes in the process responses. Such in-process effects are linked to surface quality via the use of surface roughness quantification," said Dr Kerrigan.

Milling carbon fibre reinforced plastic

> the axial location of the cutting interface on the tool has a minor effect on the milling process
>
> Dr Kevin Kerrigan

CHIP BREAKING AND COOLING TECHNOLOGIES SEMINAR

Comprehensive reviews of global research into chip breaking and cooling technologies, carried out at the Advanced Manufacturing Research Centre (AMRC) are to be used to lay the foundations for future research by the AMRC's Process Technology Group.

The reviews highlighted a series of benefits offered by cryogenic machining and emphasised the need for factors like increased friction and tool wear and reduced production rates to be taken into consideration when looking for ways to avoid problems caused by long chip formation.

Research review emphasises need to consider all options for reducing chip length

Maialen Arbide, researcher

Manufacturers seeking to eliminate problems caused by overlong metal chips forming during machining are being urged to take a comprehensive look at potential techniques and the impact they could have before opting for a solution.

The advice comes from the AMRC's Process Technology Group, following a detailed review of research from across the globe.

Researcher Maialen Arbide, who carried out the study, says each technique for eliminating problems caused by long chips; including damage to workpieces, increased friction and tool wear and reduced production rates; have different benefits and drawbacks.

She told an AMRC seminar on Chip Breaking and Cooling Technologies: "Where long chip formation is a problem, you have to take other aspects into account to ensure you choose the correct solution and not just focus on chip breaking."

Cutting tool geometry is designed to cause chips produced during machining to break off before they cause problems, but the geometry cannot break the chip in every situation.

When that happens, manufacturers could resort to 'peck' or interrupted cut drilling, high pressure coolant techniques, turn milling or vibration assisted milling, but the choice of technique would depend on a number of factors.

Peck drilling – periodically retracting the tool to clear chips – can improve life considerably, but Arbide's survey of existing research revealed uncertainty over whether the technique improves or worsens surface finish.

What was clear was that peck drilling reduced productivity and increased the time it took to complete a job.

There was also uncertainty among global researchers over the impact that breaking the chip, with a high pressure jet of cutting fluid, has on tool life and surface finish; although it is known that the high pressure coolant technique decreases the coefficient of friction for the tool's rake face and improves cooling efficiency.

However, the technique also increased costs and had an ecological impact because of the increased use of coolant.

Turn milling involved simultaneously rotating the tool and workpiece, but, while it increases tool life, while reducing thermal stress at the cutting edge and cutting forces, increased removal rates could adversely affect quality.

Meanwhile, Arbide's survey showed vibration assisted machining, combining precision machining with small amplitude, high frequency tool vibration could extend tool life significantly and improve surface finish, although more research was needed into ways of making chip formation more regular.

New, developing technologies also needed to be studied in detail to improve overall understanding of chip formation, she added.

Cryogenic machining improves surface roughness, fatigue resistance and tool life

Nacho Ballester, researcher

A series of potential benefits have been identified by international researchers studying cryogenic machining techniques, an AMRC seminar on Chip Breaking and Cooling Technologies has been told.

Nacho Ballester told the seminar researchers he had reported improved surface roughness, beneficial compressive stresses, higher fatigue resistance, better tool life and reduced cutting forces.

Both carbon dioxide and nitrogen are used in cryogenic machining, although CO_2 isn't a true cryogen.

Unlike nitrogen, CO_2 won't become a liquid at atmospheric pressure, existing instead, as a mixture of 45 per cent solid dry ice and 55 per cent gas and the temperature at which it liquefies under pressure is above -100c.

What's more, while nitrogen is inert, CO_2 can react with the surface of a metal during machining.

From a safety point of view, CO_2 presents a hazard at a concentration of 0.5 per cent in a factory, while the maximum concentration of nitrogen is 20 per cent.

Nitrogen also has greater cooling powers with a kilogram of liquid nitrogen removing 428 kJ of heat, compared with 347kJ for CO_2.

Ballester told the seminar, studies showed using nitrogen when machining nickel alloys improved tool life and reduced the friction between tool and chip, while it acted as a better lubricant than oil at low feed rates and high speeds.

There was less deformation of the surface when a minimum amount of nitrogen was used and mixing the nitrogen with a small quantity of oil could improve results, although it reduced the environmental benefits.

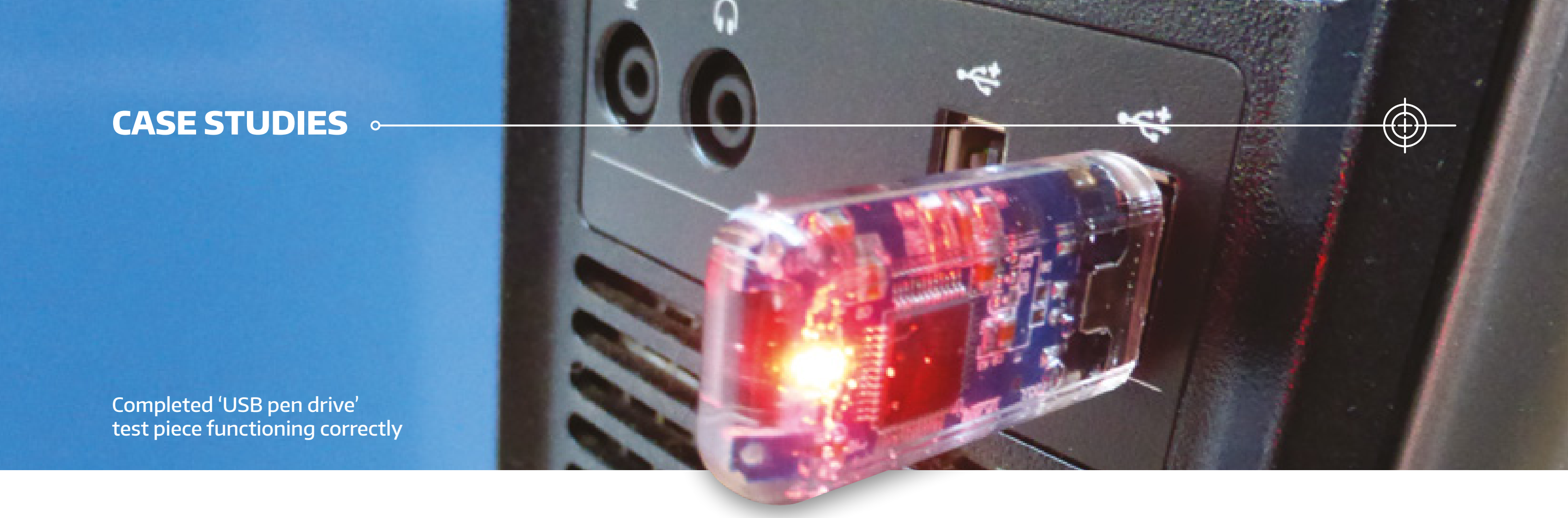
Studies showed using nitrogen when machining titanium decreased the metal's reactivity and improved tool life – but not as much as using a high pressure coolant. Best results were achieved with lower feed rates of less than 100 to 150 metres a minute, while cooling the rake and flank of the tool.

In addition to decreasing reactions between the tool and material, surface roughness improved and there was less plastic deformation. A small minority of papers suggested using nitrogen increased the hardness of the material.

Using liquid nitrogen as a coolant and lubricant when machining steel increased the life of carbide tools by a factor of three, with SNMM inserts showing the best results.

Decreases in forces depended on cutting conditions. The micro hardness of the surface increased due to changes in the microstructure, without producing white layer, while surface roughness could be decreased and compression stresses increased leading to higher fatigue resistance.

Overall, the review of studies showed cryogenic machining resulted in improved surface roughness, added compressive stress, higher fatigue resistance, better tool life and, normally, a reduction in cutting forces.



Completed ‘USB pen drive’ test piece functioning correctly

RESEARCHERS DEVELOP TECHNIQUES FOR EMBEDDING COMPONENTS DURING 3D PRINTING

Techniques developed by the AMRC Design and Prototyping Group (DPG) have increased additive manufacturing’s potential applications to include making products with embedded components.

DPG researchers set themselves the challenge of creating an additively manufactured product that contained a component that had not been additively manufactured.

They used stereolithography (SLA) to create a USB memory stick by building the case around the circuitry instead of having to make it in two halves and then join them together once the electronics had been placed in one of the halves.

Researchers chose the SLA process for the initial tests, rather than other additive manufacturing processes such as fused deposition modelling (FDM), because of the low temperature involved.

The SLA process uses a UV laser beam to trace the cross-sectional pattern of a part in a bath filled with a liquid polymer which solidifies when it is exposed to the beam.

The part is supported on a platform which is lowered in the bath after each new layer is created. A blade, known as a leveller, sweeps across the surface of the liquid polymer to ensure it is flat before the laser traces out the next layer.

Embedding components during the SLA process allows them to be permanently and securely incorporated into the polymer, which could offer better protection from dust, liquids or impacts.

It also reduces the amount of support material needed for any horizontal feature with a void underneath and could cut assembly time and post processing requirements.

However, embedding components during the build process increases the height of the finished product.

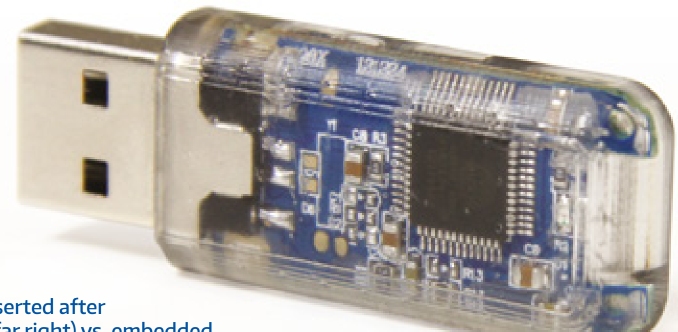
Additionally, the component can only be inserted once the solid polymer case is high enough to ensure the SLA machine’s leveller will not make contact with the component, damaging it or causing the build to fail.

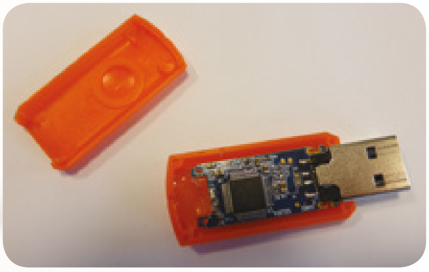
The process leaves liquid polymer sealed inside with the component which is then cured during post processing.

DPG researchers say the technique they have developed could be used to make medical products or products incorporating fixtures and fittings, as well as for electronic applications.

Knowledge gained by DPG will be used in future design projects. Further work could include investigating whether the technique offers improved protection to parts in service and ways of embedding several components in a single part.

Download the Embedding Components during the SLA Process case study at:
www.amrc.co.uk/featuredstudy/embedding-components-during-the-sla-process/





Component inserted after manufacture (far right) vs. embedded component during the SLA process (above)

Left: Absolute Engineering's five axis, CNC milling machine in action

Right: One of the products made on Absolute Engineering's five axis, CNC milling machine

AMRC showcase helps innovative manufacturing company make a TOUGH INVESTMENT DECISION

Composite experts from the AMRC with Boeing have helped a specialist local manufacturer to make a major investment in new technology.

Absolute Engineering, based at Skelmanthorpe, West Yorkshire, is a world-beating supplier of 'doctor blade' systems, which control the consumption of ink and water used in printing and coating processes.

The company pioneered the use of woven carbon fibre chambered systems which are lighter, more corrosion resistant, easier to maintain and offer higher performance than conventional metal systems.

Absolute's alternative proved so successful that it found it couldn't cope with the demand and was having to outsource some of its work, so the company sought advice from business growth service consultant, Abigail Levin, from business support specialists Chrysalis Transform.

One solution was to invest in a five axis, CNC milling machine to automate production of multiple orders, with one-offs and specials made by existing manual methods.

However, making such a significant investment was a big decision for a small firm.

Fortunately, the AMRC Composite Centre was already working with a five axis machine, and Composite Centre manager Richard Scaife and project engineer John Halfpenny were more than happy to put the machine through its paces to reassure Absolute about its performance.

John generated a number of CNC programmes that simulated the more complex tasks Absolute would need a new machine to carry out and a demonstration at the AMRC's facilities helped to convince Absolute's new American owners, global print services technology group Pamarco, to make the investment.

Abigail Levin, from Chrysalis, said: "When you are turning over £2 million, spending £350,000 on a machine is an enormous amount of money and the fact that our client was able to see and test a similar machine was fortuitous.

"Trialling the equipment at the AMRC was a big bonus and gave Absolute and its parent company confidence that the technology would work."

Richard Scaife from the AMRC said: "We were delighted to be able to play a part in helping Absolute Engineering make the right investment in new manufacturing technology. The AMRC is available to assist businesses to develop methods and techniques to advance their manufacturing technology to enable them to grow and compete more effectively".

Financial assistance for the purchase of the new technology was provided by the Leeds City Region Business Growth Programme and MAS Yorkshire, now known as Business Growth.

Abigail Levin, provided project management expertise and, with John Brannock from Absolute, organised the design and build programme which included equipment specification, installation of air filtration devices, upgrades to the electricity supply and the relocation of Absolute's canteen.

It was a hectic three months, but Absolute hasn't looked back.

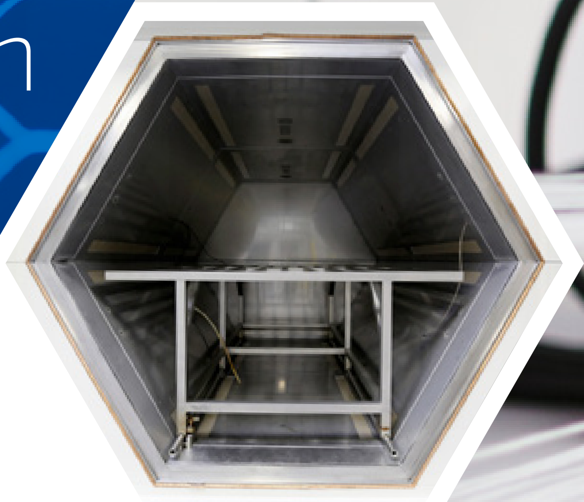
"This machine allows us to manufacture a higher quantity of chambers to an even higher standard than previously and is a reflection of Absolute's commitment to providing the very best product to our customers," said Absolute's managing director, Antony Whiteside.

"Investment in people and equipment is key to our expansion."

FEATURES

Prof Richard Day

Innovations in composite design and manufacture



Vötsch Microwave Chamber

Microwave technology fellowship could speed aircraft components production

A new initiative to drastically cut the time needed to make complex composite aircraft components has been launched with the award of a prestigious EPSRC High Value Manufacturing Catapult Fellowship.

Prof Richard Day will work with the AMRC with Boeing and the National Composites Centre in Bristol (NCC) to develop microwave technology that industry could use to cut curing times, energy consumption and greenhouse gas emissions.

Richard is Professor of Composites Engineering at Glyndŵr University, in Wrexham and an expert on the rapid manufacturing of composites, critical for the next generation of aircraft. He founded the North West Composites Centre at Manchester University before joining Glyndŵr University in 2010, where he helped form the Advanced Composites Training and Development Centre with Airbus in Broughton, Flintshire.

Prof Richard Day and AMRC colleague Betime Nuhiji working on the Vötsch Microwave Chamber

He will work closely with both the AMRC and NCC to develop microwave ovens as an alternative to conventional technology, using autoclaves – ovens that heat components under pressure.

Researchers have been using microwaves to cure composites for some years, but have yet to develop robust processes that could be used by industry to make geometrically complex parts, as opposed to flat panels.

Richard Day said: "I am delighted to be awarded this fellowship which will allow me to be embedded in two prestigious research centres and to take the results of my research from the laboratory into production.

"I'm very grateful to the companies who supported my application."

Those backing the Fellowship application included engine developers and defence and aerospace giants.

The four year research programme will explore and overcome manufacturing problems associated with microwave curing, before going on to make complex components, identical to those used in aeroplanes.

"We have a number of plans for developing the microwave curing of composites over the next four years, taking it from the laboratory and turning it into a robust industrial process," says Richard.

"It takes a long time to cure composites by conventional means and using microwaves significantly increases the speed.

"The use of composites by the aerospace industry, in particular, is going from strength to strength. More than 50 per cent of some aeroplanes are now composite and that has put pressure on the supply chain all of a sudden."

AMRC Composite Centre manager Richard Scaife said: "We see this fellowship as a strategic collaboration to further microwave technology in the UK.

"The collaboration will enable the UK to remain at the forefront of microwave processing of composite materials. We're very pleased to have Richard on board and look forward to a fruitful collaboration with all partners."

NCC collaborative research manager Dan Kells said: "We have been aware of the potential for microwave curing for a number of years. We hope that this fellowship will develop microwave curing so that it can become a real industrial process. This in turn will enable composites to continue to compete as a major structural material for aircraft and other applications."

Composite Centre's new loom ready to push the boundaries for carbon fibre fabrics

The AMRC Composite Centre's new FT Dornier Rapier Loom has begun weaving carbon fibre, opening the way to new opportunities for ground breaking research.

The AMRC's Dr Hassan El-Dessouky operating the loom

The loom is designed to weave high performance technical fibres without the risk of the highly electrically conductive carbon fibres causing it to short circuit and has been enclosed to make doubly sure that fibres will not affect other equipment.

After completing trials with glass fibre thread, the loom has successfully produced carbon fibre fabric and the Composite Centre is now seeking partners interested in pushing forward the boundaries of knowledge and improving manufacturing capabilities in a number of areas.

The Centre says partners have already expressed interest in the potential for using the loom to weave metallic filaments into carbon fibre fabrics and the loom could also play a role in research into the fundamentals of carbon fibre fabrics and how they behave when they are handled or formed into different shapes.

Researchers say developing that sort of understanding is absolutely vital as not much consideration has yet been given to the raw material and how it behaves.

The loom could also be used in research designed to improve the accuracy of simulation tools and reduce the weight and cost of composite components.

Researchers say limited understanding of the properties of carbon fibre fabrics leads to conservative designs which means more material is used than may be necessary and composite components could be as much as 50 per cent heavier than they need to be, as a result.

Better understanding of the fundamentals of the fabric and how it behaves would allow manufacturers to save on extra material and lay up costs and the loom could play an important part in creating that understanding.

The loom could also play a significant role in understanding how fibre architecture, including the tension in the warp and weft, influence the results when processes like resin transfer moulding (RTM) are used to manufacturing composite components.

Researchers also want to push the loom to the limit of its capabilities by using it to weave materials that could be opened up to form a series of boxes or a honeycomb structure that would give the completed component additional strength.

For more information, contact Dr Jody Turner: j.turner@amrc.co.uk or Dr Hassan El-Dessouky: h.el-dessouky@amrc.co.uk

ARRAY OF TECHNOLOGY MAKES 'TAKE IT FOR GRANTED' GENERATION'S IDEAS TAKE FLIGHT

A focus on instant gratification, which includes taking air travel for granted, is blinding young people to the major technological advances being made by one of the largest and fastest growing industries on the planet.

So says Madeline Kline, a 19-year-old American Business Studies student, who had her eyes opened by a visit to the Airbus factory in Bristol as part of an internship with the AMRC, before going on to tour family-owned hi-tech engineering company Castle Precision Machining.

AEROSPACE OFFERS YOUNG PEOPLE OPPORTUNITIES FOR DISCOVERY AND EMPLOYMENT

Anyone who has grown up with the ability to jump on an aeroplane and fly anywhere in the world rarely thinks about what goes into building a massive aircraft that can carry passengers safely in uncertain and ever-changing conditions.

I used to be unaware and uninterested; flying several times each year and never so much as wondering what kind of plane I was trusting with my life.

All that changed when I got the chance to tour the Airbus factory in Bristol with Colin Sirett, head of research and technology at Airbus in the UK, as my guide.

I believe now that all young people should be aware of the industry and consider the jobs it has to offer.

The Airbus site is home to a collection of giant buildings, each creating or testing a different part of the aeroplane and containing an impressive array of state of the art equipment.

Our first stop was the landing gear testing facility. Landing gear is massive. The wheels alone are as tall as I am and the entire structure weighs nearly two tonnes. Although it spends most of the flight stowed in the undercarriage it has to be able to function at extreme temperatures and on different terrains and Airbus has the technology to test the effects these factors have on all parts of their aeroplanes.

Next came the fuel test centre, with its archive of gauges, including those used in some of the earliest planes Airbus made. Fuel is something else we don't think about, but a perfect chemical balance is essential and Airbus carries out tests covering circumstances that most people would not even think to worry about.

The last stop on the tour was fascinating – the factory where Airbus wings are assembled. Not only were the wings exceptionally large, they were also mind-bogglingly complex. Every aspect of physics and engineering is taken into account in the creation of these metal and composite giants, but what really stood out was the number of people – not robots – involved in precisely building and measuring these massive structures.

I now realise the aerospace market is incomprehensibly vast and without the business leaders, creative thinkers, scholarly engineers and shop floor workers at a company like Airbus; advanced manufacturing would not be possible.

The aerospace industry is all encompassing; there are jobs to be had and discoveries to be made.

In an industry that is reliant on maintaining a delicate balance of safety, science and innovation, Airbus is creating a future for the world of manufacturing, and it is a future that young people need to be involved in.

Photo L-R: AMRC commercial director Adrian Allen, intern Madeline Kline and Airbus in the UK, head of research and technology, Colin Sirett.

CASTLE PRECISION – A SMALL COMPANY DOING BIG THINGS IN ADVANCED MANUFACTURING

Castle Precision Machining is a third generation, family-owned hi-tech engineering company in Glasgow.

Under managing director Yan Tiefenbrun's guidance, the company is currently supplying a wide variety of markets, ranging from medical to automotive to aerospace and more.

The small company is doing big things in manufacturing and, after touring its factory, I believe that Castle's approach to precision machining is truly common sense engineering.

Castle is defining precision machining with its thorough, detailed approach to manufacturing. The factory uses in-house technology to coordinate and troubleshoot machining in the most efficient way possible.

Castle is not taking an easy or cheap way out, but the company's investment in integrity and diligence pays off. Castle is constantly working to improve and manufacture the most precise and trustworthy products it can, and what it is creating can only be described as works of art.

Castle's products are manufacturing marvels, but the productivity and efficiency of the factory is equally incredible. Any cutting tool in the factory can be located in minutes with a QR code scanning system, making it easy for engineers to spend more time producing and less time looking for parts.

The computers in the factory also aid productivity by keeping close track of both the machines and those who are using them. The engineers at Castle are focused on creating the finest parts they can, and they are always improving their products and practices to provide customers with the best. The engineering taking place inside Castle's factory is logical, honest and effective.

Precision is key in everything that Castle Precision does, and by implementing this idea throughout all aspects of the company, Tiefenbrun has demonstrated that this small precision engineer can do great things.

> "Castle is defining precision machining with its thorough, detailed approach to manufacturing"
>
> Madeline Kline

CONSTRUCTION STARTS ON EUROPE'S BIGGEST FACILITY FOR PRODUCING AEROSPACE CASTINGS

Work has started on a unique facility, designed to enable UK companies to break into global markets for large-scale titanium aerospace engine and structural components weighing up to 500kg.

The initiative is spearheaded by AMRC Castings and backed by Aerospace Technology Initiative (ATI) and Catapult funding.

AMRC Castings is part of the University of Sheffield Advanced Manufacturing Research Centre (AMRC). It develops new castings technologies and provides design and manufacturing consultancy services.

The organisation has built up extensive expertise in manufacturing smaller titanium castings and licensed its technology to one company, enabling it to produce titanium castings with a poured weight in excess of 300kg, demonstrating the scalability of the technology.

Now, AMRC Castings itself is investing in a new Retech Consumable Electrode Casting Furnace, which will be the biggest furnace for casting titanium aerospace components in Western Europe.

In the past, only the United States is believed to have had the capability to cast near net shape aerospace components weighing up to 500kg.

"We are aiming to create a skills base that will enable UK companies to reap the rewards of carrying out a process that is very, very challenging," says AMRC Castings' Richard Gould.

"It takes years to develop the skills and techniques to produce titanium castings. There are relatively few players in the market, who are very protective of their capabilities.

"Any UK company wanting to break into the market would have to develop the know-how themselves, but we aim to build up the know-how for the benefit of the UK advanced manufacturing and aerospace industries.

AMRC Castings already operates two Induction Skull Melting (ISM) furnaces, which can produce castings weighing up to 30kg and 90kg respectively.

ISM furnaces use water cooled segmented copper crucibles to melt pre-analysed titanium in a vacuum, avoiding the extreme reaction that would occur if the metal was melted in a conventional refractory lined furnace or in the air.

AMRC Castings' new furnace uses Vacuum Arc Remelting (VAR) technology. It will strike an arc between a cooled copper crucible and an electrode of titanium with a certified purity, which will gradually melt.

While the ISM method uses cheaper raw material and achieves higher super heat – the temperature to which the metal is raised above its melting point – the VAR method is more suitable for larger volumes, uses less power per kilo melted, has a faster turnaround and has lower maintenance costs because it uses a single piece crucible.

AMRC Castings' furnace will have three interchangeable bodies, allowing it to produce castings from 125kg to 500kg – which, at the top end, means it has to be able to melt 1000kg of titanium.

That means it will be able to make castings that are up to two metres in diameter and 2.5 metres long – large enough for an aero engine intercase.

"There are a number of ways of making aero engine casings – such as complex fabrications or heavily machined parts

> "...enable UK companies to reap the rewards of carrying out a process that is very, very challenging"
>
> **Richard Gould**
> **AMRC Castings**

or you can buy castings from the US," says Richard Gould.

"Britain hasn't got the capability at present, but we plan to create a world class titanium casting capability for the UK."

Having the different sized bodies will allow AMRC Castings' researchers to build up their expertise on smaller castings before tackling a 500kg intercase – the largest intercase that is made.

It also gives the organisation greater versatility for the long term, in terms of the range of titanium castings it can produce.

"It took a huge effort to perfect techniques for producing titanium castings weighing 30kg and a further effort to raise that to 90kg," says Richard Gould.

"With the new melter we can ramp up our knowledge base and we have the equipment to grow with us."

Artist's impression of AMRC Castings extension. Bond Bryan Architects.

FURTHER INVESTMENT WILL SUPPORT NEW AMRC CASTINGS FURNACE DEVELOPMENT

AMRC Castings' 1000 kg furnace will be just one part of a major investment and R&D programme at its headquarters on the Advanced Manufacturing Park at Catcliffe, near Rotherham.

The organisation has acquired an SLA 3D printer, with ATI backing, that allows it to make replica patterns that are up to 650mm by 750mm by 550mm from photosensitive epoxy resin.

AMRC Castings will take functional designs from an OEM and using its skills and software that simulates how a mould fills and solidifies, design replica patterns incorporating the feeding and gating system for the molten metal.

Its CAD system will then be used to design high precision components that can be combined to create a sacrificial replica pattern and feed the data to the new 3D printer and existing CNC machines, which will make the parts from epoxy and polystyrene, respectively.

Parts can be joined together to create a complete pattern and then coated with ceramic in a new 'Titanium MEGAshell' facility, capable of making ceramic shells that are up to two metres in diameter, 2.5 metres high and weigh more than 2.5 tonnes

AMRC Castings already has considerable expertise in making ceramic shells for its Replicast® process, which uses replicas which can be machined or blow moulded from polystyrene or built up using additive manufacturing (AM) techniques.

process and has been used to produce castings weighing up to 3,500kg from non-reactive metals.

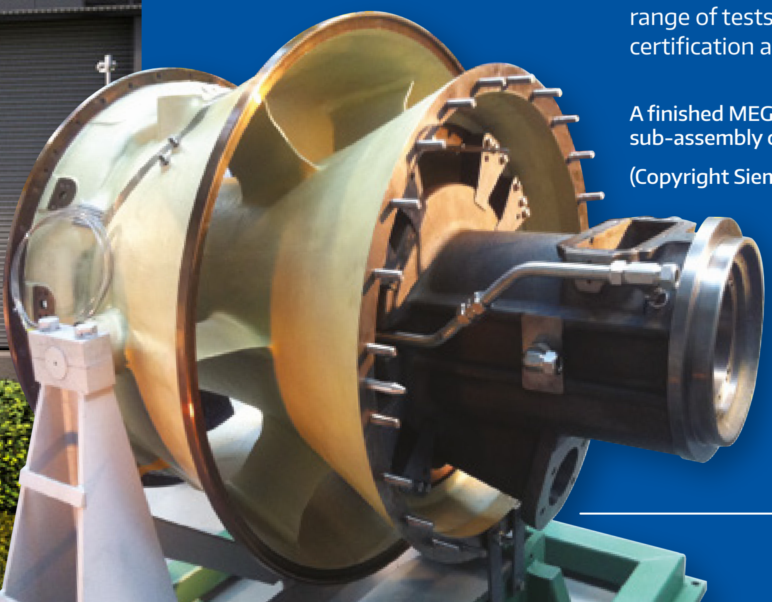
With Replicast®, the ceramic shells are put in casting boxes and surrounded with refractory sand. The boxes are then shaken on a vibrating table and the air is drawn out of the sand to create a firm support for the shell.

Since melting and pouring titanium has to be done under a vacuum, that won't be possible with the titanium MEGAshell® process and the shell alone will have to support the weight of the metal.

One of the research and development challenges AMRC Castings will have to meet is to make shells which, after firing to remove the epoxy and polystyrene, are so clean that there is no reaction with the titanium during casting and produce castings that require the minimum amount of welding upgrades.

As part of the titanium MEGAshell® development, AMRC Castings is also investing in inert atmosphere welding facilities and vacuum heat treatment furnace and finishing capabilities.

The organisation will work with industry partners who will carry out hot isostatic pressing (HIP) and chemical milling of the finished castings and use its own laboratories to undertake the comprehensive range of tests required for full certification and accreditation.



A finished MEGAshell® casting in a sub-assembly of an industrial gas turbine.

(Copyright Siemens Industrial Gas Turbines)

AMRC Training Centre **Courses**

All courses held at the AMRC Training Centre, Rotherham, S60 5BL

24 November
An Introduction to Advanced Machining Technologies

A one day course providing an overview of a selection of advanced machining technologies in the context of nuclear engineering.

30 November
Non-Ferrous Alloys

A technical course describing the production, features and applications of aluminium, copper, nickel and titanium alloys.

1 December
Fundamentals of Metallurgy

This course provides an introduction to the principle alloy categories and their applications. It explains the properties of metals, how they are tested, how metal products are made and where they are used.

8 December
Carbon and 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.

9-10 December
Triple Bar for Nuclear Manufacturing

The Triple Bar for Nuclear Manufacturing (TBNM) has been developed by nuclear manufacturers for nuclear manufacturers. It gives individuals working in the manufacturing sector a sound understanding of what differentiates nuclear from other industries.

15 December
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.

21 December
Stainless Steel Metallurgy

A one day technical course covering all aspects of the production and use of a range of stainless steel alloys.

26 January 2016
Principles of Testing and Quality Assurance

A one day course providing delegates with an understanding of the principles of testing and quality assurance systems for improving a process/business/testing systems.

27-28 January 2016
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.

3 February 2016
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.

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