NAMTEC’s Direct Company Support programme exceeds all its targets

See page 9-11

Page 6
Close Brothers launch innovative apprenticeship scheme for SMEs

Page 7
AMRC designers win top prize: UK Space Propulsion Innovation Awards

Page 12
Cryogenic machining improves sustainability & quality

Page 14
Virtual machining targets cuts in production times and costs

Page 26
NAMTEC: Supply Chain Opportunities in Oil and Gas
This month sees the successful completion of a four year programme, launched by NAMTEC to help companies rapidly achieve significant business improvements.

The Direct Company Support Scheme and related “Two Day Assist” initiative was aimed at companies across Yorkshire and the Humber, and Small and Medium-sized Enterprises (SMEs) in particular.

The European Regional Development Fund backed programmes helped companies tap into the wealth of expertise in commercial consultancies and research organisations that exists in this region.

Both programmes have been a major success, reaching more companies and leading to the creation and safeguarding of far more jobs than had originally been expected.

We are continually told that we need to be more productive and competitive. That can mean investing in new products and processes.

It can also mean investing in people and this latest issue of the Quarterly Journal includes good news for SMEs that would like to invest in skills for the future by taking on an apprentice, but are worried about the cost.

The Close Brothers SME Apprentice Programme has been launched by the leading merchant bankers, with the support of the University of Sheffield AMRC Training Centre and the Manufacturing Technologies Association (MTA).

It will help pay for 20 apprentices to learn their skills at the AMRC Training Centre and ensure participating SMEs won’t have to bear the full cost of employing the apprentices until they can make a positive contribution to their business.

We also need to invest in new markets and the report on NAMTEC’s recent conference on the oil and gas sector shows there are still opportunities in the sector’s supply chain, despite falling prices and increasing pressure to reduce costs.

Some of the opportunities are the result of the pressure to reduce costs, while others are posed by the increasingly challenging conditions oil and gas companies are having to operate under as they seek to exploit harder to extract reserves.

Last, but not least, as both the Factory 2050 and Sir Henry Royce conferences demonstrated, there will continue to be a need to invest in introducing cutting edge technology if we are to remain a global force in advanced manufacturing.

The need to develop that technology and ensure it can easily be introduced by industry will be one of the key drivers behind the ambitious plans for a major expansion of the AMRC on a 50 acre site, close to its existing facilities, also detailed in this edition.

Contents

General News  page 3-5
AMRC News  page 6-7
Features

Masterplan lays foundation for new expansion of pioneering Advanced Manufacturing Research Centre  page 8
NAMTEC’s Direct Company Support programme exceeds all its targets...  page 9-11
Cryogenic machining improves sustainability & quality  page 12-13
Virtual machining targets cuts in production times and costs  page 14-15

Event Reviews

Factory 2050  page 16-25
NAMTEC: Supply Chain Opportunities in Oil and Gas  page 26-27
Materials for Manufacturing – Sheffield: the Sir Henry Royce Institute and the Innovation District  page 28-30
Case Study

Howco Group: Oil and gas sector materials specialist acts to cut energy consumption  page 31
Upcoming Events & Courses  page 32
The power and automation specialist will service 54 Siemens wind turbines fitted with 3.6MW ABB generators in the Lynn & Inner Dowsing (LID) offshore wind farm.

The generators have been operating since 2009 and provide enough electricity for half the homes in the English county of Lincolnshire.

Power is transmitted via subsea cables to shore and then by underground cables to a new substation at Middlemarsh, Skegness.

ABB’s contract includes the electrical maintenance and support services for onshore and offshore electrical equipment. Electrical equipment covered by the preventive maintenance contract includes generators, converters and onshore substation and offshore transformers, switchgear and cabling, along with onshore substation emergency response. Mechanical, control and other support activities are being supplied by LID and other partners.

Peter Wright, ABB’s service manager, said: “The idea of working directly with a wind farm operator was attractive to us as normally our work is through OEMs.

“The contract shows how ABB can combine skills and knowledge from across its organisation to provide a tailor made servicing solution for clients.”

In order to win the contract, ABB had to demonstrate it could support the third party equipment as well as its generators, along with its partnership capabilities and its high regard for health and safety, for which it achieved the highest score in the tender process.

Avianca will use the new aircraft to replace aircraft currently operating from its Bogota, Lima and San Salvador hubs, allowing it to maintain one of the youngest fleets in the region.

Fabio Villegas Ramirez, Avianca Chief Executive Officer, said:

“Thanks to the A320neo family’s fuel efficiency, technical reliability and unique passenger comfort, we can further Avianca’s fleet modernisation process, while connecting the region and supporting its development.”

John Leahy, Airbus chief operating officer, customers, said: “For over 15 years, Avianca has benefited from the excellent operating economics and award-winning reliability of the A320 family.

“The A320neo brings Avianca the highest efficiency at the lowest cost, making it ideally suited to operate within their network and especially within the region’s challenging airports.”

Avianca and is the second oldest airline in the world and was the first airline in the Americas.

Airbus says its A320 family is the world’s best-selling single aisle product line with more than 11,500 orders to date and over 6,400 aircraft delivered to 400 customers and operators worldwide.

The newest member of the A320 family, the A320neo, incorporates many innovations including latest generation engines and Sharklet wing tip devices, which together deliver more than 15 percent in fuel savings from day one and 20 percent by 2020.

According to Airbus’s latest Global Market Forecast, international traffic serving Latin America is likely to grow by 6.2% by 2033, just behind Africa, where the market will grow by 6.3%. The Middle East will grow by 5.4% and Asia by 5.1%, still well above the world average of 4.7%.
BAE Systems adapts Formula 1 technology for use on military vehicles

Active damping technology from Formula 1 is being used to increase the speed and agility of tracked military vehicles over rough terrain.

Engineers at BAE Systems have upgraded members of the CV90 family of combat vehicles with the technology, which first appeared in Formula 1 in the 1990s.

The suspension system usually operates on carbon fibre racing cars weighing no more than 700kg, but engineers at BAE Systems have adapted it for use on vehicles weighing as much as 35 tonnes.

The system works by sensing the speed of the vehicle and lay-out of the terrain ahead and responding by pressurising the suspension to keep the vehicle on a level plane at all times.

It has reduced the CV90s pitch acceleration by approximately 40 per cent, increasing its stability and helping to reduce the wear and tear on the armoured vehicles and reducing through-life repair costs, despite speeds over rough terrain rising by up to 40 per cent.

In recent trials a CV90 fitted with active damping set a new speed record on a rough terrain course, beating the main battle tanks.

Dan Lindell, CV90 Platform Manager at BAE Systems, said: “Adapting the Active Damping system for the first time from a light weight car to a heavy tracked vehicle such as CV90 was a unique challenge for us, but this advanced technology will deliver results to our customers in terms of vehicle performance and savings on the through life costs, as well as providing real benefits to the front line soldier”.

The CV90 is one of the largest families of armoured combat vehicles and is currently used in countries such as Norway, Finland and Denmark. It has also been used in global operations including UN and NATO collaborations.

Heatric heat exchangers enable low-cost, CO² emission-free energy power generation

Meggitt subsidiary Heatric has been chosen to supply special heat exchangers for a revolutionary natural gas-fired power station offering low-cost energy with no carbon dioxide emissions.

The multi-million pound contract involves supplying four recuperative heat exchangers for a pilot plant being developed by NET Power in Texas.

Heatric’s printed circuit heat exchangers have a diffusion-bonded design, capable of withstanding the very high temperatures and pressures of the plant’s core process.

The heat exchangers will make a critical contribution to the economic viability of the pioneering new plant by capturing and recycling a significant proportion of the turbine exhaust energy flow and reducing the amount of fuel required by the plant.

The contract represents a new opportunity for Heatric, which has already supplied more than 2,500 heat exchangers for oil and gas platforms, most recently, floating production, storage and offloading vessels and floating liquid natural gas remote offshore gas processing vessels.

Heatric chief executive, Stephen Young, said: “This new contract shows Heatric working closely with customers to develop new and exciting applications in adjacent fields.”

While most fossil fuel-based power plants use the heat from burning fuel to turn water into steam which powers the generating turbines, NET Power’s technology burns fuel in pure oxygen and recycles the resulting CO², creating a mostly pure high pressure stream of supercritical CO² that powers the turbines.

Excess CO² can be used by industry or fed into a Carbon Capture and Storage scheme.
Rolls-Royce has won its largest ever order to provide Trent 900 engines and TotalCare service support from Emirates Airline. The deal is worth $9.2bn and means the Trent 900 will be used to power 50 Airbus A380 aircraft that will enter service from 2016. Rolls-Royce says the decision confirms the Trent 900 as the engine of choice on the four-engine A380.

The Trent 900 powered the first commercial A380 in 2007 and is now used by eight operators on more than 70 aircraft, having logged over four million in-service flight hours.

Rolls-Royce says the Trent 900 offers the lowest lifetime fuel burn, with the latest version including technology developed for the Trent XWB and Trent 1000 engines.

Emirates Airline’s president, Sir Tim Clark, said: “Rolls-Royce is a key partner for Emirates and we have been impressed with its commitment to continual improvements in the economic and operational performance of the Trent 900.

“These improvements have been decisive factors in our selection of the product for 50 of our A380s.”

Rolls-Royce’s Chief Executive Officer, John Rishton, said: “The success of Emirates over the last 30 years has been extraordinary; this is in no small part thanks to the exceptional leadership of Sir Tim Clark.

“Rolls-Royce has been proud to have been part of this success, powering Emirates aircraft since 1996. We are delighted that Emirates has again placed its trust in our technology, with the biggest order in our history.”

The deal is good news for ITP, which is an exclusive partner in the design of the Low Pressure Turbine (LPT) for Rolls-Royce’s larger engines and has developed all of the large LPTs for Rolls-Royce engines since the Trent 500. ITP is a risk-revenue sharing partner with Rolls-Royce in the programme and says the order means it will secure expected sales in excess of $1.4bn.
Close Brothers launch innovative apprenticeship scheme for SMEs

Leading merchant banking group Close Brothers has launched a pioneering programme to help small and medium-sized enterprises (SMEs) in the Sheffield City Region secure the skills they need for future growth...

Through the ‘Close Brothers SME Apprentice Programme’, Close Brothers will contribute to the cost of apprentices for 20 SMEs who might otherwise be unable to afford to take on a new apprentice.

With the support of the University of Sheffield AMRC Training Centre and the Manufacturing Technologies Association (MTA), the programme will help SMEs recruit and train a new generation of advanced engineering workers. Under the scheme, Close Brothers will help pay for 20 apprentices to learn their skills at the AMRC Training Centre.

Close Brothers will fund half of the new recruits’ wages during the first year and a quarter in the second, meaning participating SMEs won’t have to bear the full cost of employing the apprentices until they are making a positive contribution to their business.

The objective is to recruit a further 20 apprentices in year two and 20 more in year three, meaning Close Brothers will be supporting up to 60 apprentices in the scheme at full capacity in what is a banking first.

For more information please visit the Training Centre website: www.amrctraining.co.uk

Research aims to push the boundaries of composites

Experts at the University of Sheffield AMRC with Boeing are aiming to push the boundaries in two important areas of composites manufacturing.

The AMRC’s Composites Centre has invested in an FT Dornier Rapier Loom, so that it can design and weave material and push the boundaries of processes like Resin Transfer Moulding (RTM).

Meanwhile, the announcement of a prestigious EPSRC High Value Manufacturing Catapult Fellowship could result in the development of microwave technology that will cut curing times, energy consumption and greenhouse gas emissions.

Resin Transfer Moulding is supposed to be a very rapid and highly production orientated process, but sometimes the resin doesn’t penetrate all of the material.

The loom will be used to help researchers to understand more about what happens during RTM injection, while also pushing the loom’s capabilities to see if it can weave materials that could be opened up to form a series of boxes or a honeycomb structure to provide additional strength.

The new Catapult Fellowship to study microwave curing has been awarded to Richard Day, Professor of Composites Engineering at Glyndŵr University, in Wrexham.

Richard is an expert on the rapid manufacturing of composites, critical for the next generation of aircraft and will work with the AMRC Composites Centre and the National Composites Centre in Bristol (NCC).

His 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,” said Richard.

Researchers from the AMRC have already achieved some successes with microwave curing.

A partnership involving the Composite Centre, South Korean research centre KCTECH (Korea Institute of Carbon Convergence Technology) and the Ssangyoung Motor Company won 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.
Sam Hyde and Valdis Krumins beat 14 finalists from leading space science companies, design agencies and university research centres to win the overall UK Space Propulsion Innovation Award. They won the award for a new design for “permanent valves” – valves that operate only once during a space mission and then remain open or closed.

Existing valves are opened or closed permanently by firing a small explosive charge. The method poses dangers for people handling the valves before launch and can damage a satellite or rocket in space. Sam and Valdis replaced the explosives with a simple spring which is compressed and secured by a piezoelectric trigger. When current flows through the trigger, it releases the spring, which pushes the valve into its new position. The trigger returns to its original position when the current is switched off and then prevents the valve from moving back. Sam and Valdis also changed the shape of the valve from a cylinder to a tapered cone, to create a better seal.

“I think we won because we have the capability to look at things differently at the Design and Prototyping Group,” says Valdis. “Using explosives to operate the valves had almost become the ‘industry standard.’ We won because ours was a fresh look at the problem.” Sam adds: “One of the beauties of working in the AMRC’s Design and Prototyping Group is that it brings together people from a wide range of different backgrounds who share ideas and bring a lot of experience to the table.” Sam and Valdis will use the £10,000 top prize to further develop their design.

A seventeen year old apprentice from Sheffield-based automotive tools specialist Eldon Tools has won the trip of a lifetime to visit Boeing Commercial Airplanes in Seattle, to see the aerospace giant’s new Dreamliner being made.

A seventeen year old apprentice from Sheffield-based automotive tools specialist Eldon Tools has won the trip of a lifetime to visit Boeing Commercial Airplanes in Seattle, to see the aerospace giant’s new Dreamliner being made.

Russell Fox, from Atherton Road, Arbourthorne, in Sheffield, won the trip by being named the AMRC Training Centre’s Boeing Apprentice of the Year.

Russell later went on to be named Apprentice of the Year at the Made in Sheffield Awards. A total of 10 awards were presented to AMRC Training Centre apprentices at a celebration dinner, held at Firth Hall. Winners included AMRC Training Centre trainer John Dobinson, who was named Mentor of the Year by apprentices because of his enthusiasm, use of different teaching methods and ability to motivate.

Other award winners were: Sandvik Coromant Machining Apprentice, Ross Copel, from Maher; Oerlikon Fabrication and Welding Apprentice, Liam Webster, from the Nuclear AMRC; Cromwell Maintenance Apprentice, Jonathan Watson, from Nikken Kosakusho Europe; Hexagon Metrology Technical Support Apprentice, Bradley McDonald, from Sheffield Forgemasters International and Apprentice Employment Agency Business & Administration Apprentice, Stacey Curtis, from University of Sheffield.

Special Recognition Awards, sponsored by Haas, Huwema and the MTA were presented to Jack Wilsher-Hepworth of AESSEAL, Kesson Lomas of Lomas Engineering and the AMRC Training Centre’s Master Cutler’s Challenge Team.

Jack received a special recognition award for the voluntary work he has done, promoting the AMRC Training Centre. Kesson received her award for the progress she has made throughout her engineering apprenticeship and the Master Cutler’s Challenge Team received its award for raising more than £7,000 for the Whirlow Hall Farm Trust and Sheffield Hospitals Charity.
The University of Sheffield has submitted a masterplan for a new large scale expansion of its Advanced Manufacturing Research Centre.

The masterplan envisages building up to 1.3 million square feet of state of the art research facilities, dedicated to boosting the competitiveness of the advanced manufacturing sector.

The new campus, on 50 acres of land at Sheffield Business Park, would be expected to attract cutting edge companies offering hundreds of well-paid, hi-tech jobs and bring millions into the region.

Up to 1,800 new jobs could be created and the local economy could benefit to the tune of £74.2 million a year.

The AMRC’s executive dean, Professor Keith Ridgway CBE, said the plans will lead to a step change in the University of Sheffield’s ability to work in partnership with some of the world’s leading companies.

“We already have fantastic relationships with a number of leading aerospace and engineering companies and we’ve proved over the last decade that there is an enormous appetite from industry for the innovative work we do here,” said Professor Ridgway.

“The submission of the masterplan is another step towards significant expansion that will put the AMRC in an even stronger position to transform research into practical applications which offer high-tech solutions right across the manufacturing sector.

“If we are successful in our other plans for the Sheffield Business Park site, it will act as a catalyst for the development of an Advanced Manufacturing Innovation District, bringing more leading manufacturers to the region, reinforcing its place as an international leader in high value manufacturing.”

The submission of the masterplan to Sheffield City Council is the latest milestone in a process that began a year ago, when the university secured the land on Sheffield Business Park, not far from the AMRC’s headquarters on the neighbouring Advanced Manufacturing Park (AMP).

The next step came last September when work started on the first development on the new site, the £43 million Factory 2050, which will be the UK’s first totally reconfigurable, digital factory, built to respond to an increasing requirement for advanced manufacturers to be able to make rapid changes to product design, as a result of ever-changing customer demands.

The site could also be home to the Sir Henry Royce Institute for Advanced Materials’ Sheffield arm - a £30 million centre focusing on the development of powder metallurgy, new high strength, low weight materials and the techniques manufacturers will need to make components from those materials.

The masterplan is also a step towards the development of the UK’s first Advanced Manufacturing Innovation District – which could become one of Europe’s largest research-led advanced manufacturing cluster, centred on the M1 corridor near Sheffield and Rotherham, and already home to the AMRC’s facilities at the AMP.

Innovation Districts combine research institutions, innovative firms and business incubators with the benefits of urban living. Unlike traditional science parks, these districts cluster cutting-edge research in geographic areas that are liveable, walkable, bikeable, and transit connected.
NAMTEC’s Direct Company Support programme exceeds all its targets

A four year programme to help advanced manufacturing companies across Yorkshire and Humber to grow has beaten all the targets it was set.

The Direct Company Support Scheme was launched in 2011 by the National Metals Technology Centre (NAMTEC) after it secured substantial backing from the European Regional Development Fund (ERDF).

The scheme was aimed at companies needing help with projects intended to have a high impact on their business in a comparatively short time.

Projects spanned the development of new and existing products and processes, the introduction of new materials and factory layouts.

Funding typically ranged from £5,000 to £20,000 and was used to finance assistance by specialist consultants and university researchers.

Small and Medium-sized Enterprises (SMEs) could could recoup up to 70 per cent of their costs, while large regional companies would get 60 per cent back.

NAMTEC also used ERDF funding to offer SME advanced manufacturers across Yorkshire and the Humber two days of free support from specialist consultants, worth around £850 and designed to improve their capabilities, help them explore new markets and solve technical issues.

Dr James Hughes, director of NAMTEC, which is part of the AMRC, said: “Both schemes have been a major success.

“We exceeded all the targets we had been set – in some cases three or four times over – and we were able to help companies ensure that key projects went ahead which might otherwise never have happened.

“We were also able to help companies from a wide range of sectors - spanning forging and healthcare, precious metals and powder metallurgy, packaging and steel stockholding.”

In all, more than 110 SMEs received help - around 10 per cent up on the original target. Around 70 of the companies were from South Yorkshire, around 30 per cent up on target.

The initiative led to more than 85 jobs being created and nearly 500 safeguarded – around double the original targets. The numbers of jobs for women and people from Black and Ethnic Minority Communities that were created or safeguarded were also well ahead of targets set at the start of the programme.

In addition to negotiating the funding, administering the initiative and pulling together the team of consultants, NAMTEC also helped some companies to formulate their projects and ensured the application process was as simple and fast as possible, with decisions being made in less than a fortnight.
Direct Company Support Scheme’s successes continue as programme winds down

Mailway
Leading UK packaging and delivery services specialist Mailway was able to achieve new growth, greater efficiency and increased customer satisfaction after introducing Lean techniques, with the help of consultants Director Resource. Improvements included a 15 per cent increase in stock utilisation and a 40 per cent improvement in the efficient use of forklift movements.

Bifrangi UK
Bifrangi UK, the specialist manufacturer of large crankshafts for the agricultural, off-highway, marine, power generation and mining sectors, was able to reduce its overheads and lost productivity with the help of Brook Corporate Developments. The company was also able to minimise the need for straightening and post hardening, reduce thermal cracking, improve surface finishing techniques and reduce scrap in the induction hardening process.

Advanced Manufacturing
When Advanced Manufacturing decided to introduce formal quality management systems, following rapid growth in aerospace contracts, the company secured the help of ICE Partnership, with backing from the Direct Company Support Scheme. As a result, the manufacturer of complex components from challenging materials for research and development projects was able to take part in the 21st Century Supply Chains (SC21) programme, reducing defects and boosting delivery performance in the process.

Cutting & Wear
Following a move to a purpose built facility, international oil and gas drilling industry supplier Cutting & Wear decided to seek ways of boosting performance and making the most of opportunities in new markets.
With advice from Director Resources, the South Yorkshire company upgraded its Enterprise Resource Planning software and introduced 5S workplace organisation principles and Lean workshops, helping it to significantly increase its engineering efficiency and its record for fulfilling orders and enabling it to achieve world-class performance standards.

**Diamond Dispersions**
Diamond Dispersions, the award-winning exporter of concentrated pigments and dyes for hi-tech ink jet printers is hoping to move into what could be the fastest growing technology in the wide format digital printing market as a result of its participation in the Direct Company Support Scheme.

Harriton Services, the Lincolnshire-based materials and commercial consultancy, helped Diamond Dispersions to investigate opportunities to make UV-curable ink dispersions, which can be used to make inks which produce high quality images, faster and at lower costs, improving productivity, reducing waste and avoiding the environmental impact of solvent-based inks.

**Hydraulic Systems**
New opportunities for growth, including job creation, opened up for Hydraulic Systems Products (HSP) after it used the Direct Company Support Scheme to help it upgrade its product development capabilities.

Brook Corporate Developments was called in to advise the Wakefield firm, helping it to turn partially developed drawings for a new product range into 3D CAD models.

HSP and Brook went on to generate models, manufacturing drawings, marketing materials and datasheets for new and existing products and identified new market opportunities.

**Billington Structures**
Leading UK structural steelwork contractor Billington Structures is targeting a 20 per cent increase in throughput of its paint shop after changing the way it heats its factory and improving planning and forecasting systems.

Multidisciplinary environmental and industrial consultant Pro Enviro helped Billington to lower drying times and reducing scheduling and planning delays. Recommendations included reconfiguring space heating to create a more even temperature, allowing for the creation of areas of concentrated heat for rapid drying.

**Wintwire**
Speciality wire products manufacturer Wintwire is targeting growth, after a detailed rethink of production systems and controls improved its ability to compete with lower cost rivals.

Brook Corporate Developments advised the company, based near Barnsley, about ways to increase its operational effectiveness and efficiency, while ensuring high levels of customer satisfaction. A model was developed that has enabled the firm to make the right decisions about production routes, lead times and making the best use of staff time.

**Disposables UK**
When paper products manufacturer and distributor Disposables UK wanted to improve its efficiency and competitiveness, reap the maximum benefits of a £1 million investment in automation and create capacity to grow, Brook Corporate Developments was on hand to provide the appropriate advice.

With Brook’s help, Disposables UK moved operations spread across four factories to a single site, developing the ideal layout for its equipment and introduced a continuous improvement culture.
Cooling components with liquid nitrogen and carbon dioxide during machining can create super refined surfaces with similar properties to advanced coatings, according to Professor Ibrahim Jawahir, from the University of Kentucky.

Professor Jawahir, founding director of the Institute of Sustainable Manufacturing, was speaking at a seminar at the AMRC.

He told the seminar that recent research showed cryogenic machining could transform metals in the solid state, turning the microstructure of the surface into a nanostructure. The effect could increase hardness at the top surface, improve quality and reduce corrosion rates, while also reducing tool wear.

Using nitrogen meant there were no negative health or environmental problems that might be associated with other coolants and lubricants, increasing the sustainability of the process.

Professor Jawahir said sustainability was a word that was heavily used and abused these days. As far as manufacturing was concerned, sustainability involved reducing negative environmental impacts, improving the efficient use of energy and resources and generating as little waste as possible.

It also meant improving operational safety and personal health, whilst maintaining or improving product and process quality and creating overall life cycle cost benefits – something manufacturers often lost sight of.

Sustainable manufacturing covered the whole of the product life cycle from pre-manufacturing extraction and processing of raw materials through to the retirement, treatment and disposal of products at the end of their useful life.

Professor Jawahir said that all too often too many resources and too much energy were used, while too much waste and too many emissions were created when a product was disposed of.

There was a need to redesign and remanufacture products to ensure their re-use and to recycle and recover as much as possible.
When it came to assessing the sustainability of a product, process and associated manufacturing systems, it was easy to measure factors like manufacturing costs, energy consumption and waste management.

Measuring how environmentally friendly and operationally safe a product was and the impact manufacturing and using it had on personal health was more difficult, but could be derived using ‘Fuzzy Logic.’

When it came to sustainable machining, the general aim was to minimise cutting forces, power, torque and tool wear.

Traditional coolants had become a ‘necessary evil’ in the machining process, but tended to be used indiscriminately, and they did not do much to improve the quality of products, the health of the users and overall recyclability.

Dry machining and near dry machining – also known as Minimum Quantity Lubrication, or MQL – was more sustainable, while cryogenic machining or the combination of cryogenic and MQL techniques, was even more sustainable.

Professor Jawahir was accompanied during his visit to the AMRC by Professor David Aspinwall, Dr Leung Soo and Dr Richard Hood from the University of Birmingham.

The group was hosted by Dr Erdem Ozturk and had an opportunity to see the AMRC with Boeing’s Factory of the Future, Composite and Knowledge Transfer Centres.

A number of AMRC technology and platform groups demonstrated their capabilities and shared recent findings with the visitors.

The effect could increase hardness at the top surface, improve quality and reduce corrosion rates, while also reducing tool wear.

After the seminar, representatives from the Universities of Sheffield, Kentucky and Birmingham discussed the potential for collaboration.
Engineers at the AMRC with Boeing and representatives of partner companies have heard how colleagues in Canada are seeking to take trial and error out of the process of machining newly designed components using simulations for virtually testing and optimising machining operations.

Professor Yusuf Altintas, a leading expert on virtual high performance machining, from the Department of Mechanical Engineering at the University of British Columbia visited the AMRC to deliver a seminar on virtual high performance machining. Research by Professor Altintas and his colleagues aims to reduce production times and costs by minimising prototype testing of machine tools and machining operations.

Their virtual machining model predicts the cutting forces, torque and power consumed when machining parts by considering material properties, cutter geometry and cutting conditions along the tool path.

“We have one huge mathematical model which is good for any machining operation, serrated tools and indexed cutters, and our most recent work in the auto industry has been with multi-functional tools,” Professor Altintas told delegates attending the seminar.

Professor Altintas said the model could take finite element analysis data produced as part of the machine tool design process and use it to study the operation of a cutting tool before the machine tool had even been built.

The software was being used by more than 200 companies and research centres worldwide, including the AMRC, and had been used to tailor make a machine tool spindle for a particular process, eliminating problems which had resulted in one major aerospace company having to replace spindles frequently.

Professor Altintas’s team is currently investigating the
damping of machine tool vibrations, the stability of turning, drilling, boring, micro-cutting, pipe threading and mill turn operations.

Professor Altintas was making his second visit to the AMRC, having first been here 15 years ago.

The latest visit was organised by Dr Erdem Ozturk.

During his visit, Professor Altintas toured the AMRC’s Factory of the Future, Integrated Manufacturing Group, Composite and Design and Prototyping Centres, as well as the Nuclear AMRC, taking the opportunity to view their capabilities and new developments.

Professor Altintas also took part in meetings which identified several themes for future collaboration between the AMRC and the University of British Columbia’s Manufacturing Automation Laboratories.

After the seminar, Professor Altintas signed a copy of his book – Manufacturing Automation-Metal Cutting Mechanics, Machine Tool Vibrations, and CNC Design* – for Ozan Gurdal, an MSc student on the AMRC’s Advanced Manufacturing Technologies programme, who is currently working on a thesis on modelling the effects of process damping in milling, supervised by Dr Erdem Ozturk and Professor Neil Sims.

*Manufacturing Automation-Metal Cutting Mechanics, Machine Tool Vibrations, and CNC Design is one of the most cited books in metal cutting research and applications.

“We have one huge mathematical model which is good for any machining operation, serrated tools and indexed cutters”
Drones to deliver on logistics and metrology in tomorrow's factories?
Aiden Lockwood, AMRC

The commercial market for drones is taking off with more than 40,000 due to be sold this year and that number expected to triple over the next three years.

As part of that revolution, we could see multi-rotor helicopter drones flying around Britain's factories, carrying out a number of different roles, according to Dr Aiden Lockwood, senior project engineer with the AMRC's Integrated Manufacturing Group.

Multi-rotor helicopters could be used in high value manufacturing for logistics – distributing tools to workstations, for example, for advanced metrology and high resolution visual inspection.

Use for logistics posed a number of safety and other issues.

“How do you path plan, particularly if you have multiple objects around the shop floor?,” asked Aiden.

Safety systems would have to be created, including, possibly, no fly zones, which, in the case of cranes and lifts, might have to move as the crane or lift moved. The helicopters themselves would also have to know they had sufficient energy to complete a job and return to a charging station.

Multi-rotor helicopters could be used to provide high speed visual mapping within the next generation of advanced factories and for initial inspection, highlighting areas of larger components requiring greater inspection.

It should also be possible to laser scan Unmanned Aerial Vehicles (UAVs) like multi-rotor helicopters as they move, mapping where the UAV was in a 3D volume very precisely, to build up a high resolution telemetry system.

Manufacturing technology must put people first and eliminate the barriers caused by current IT systems, if we are to create the intelligent, scalable and flexible factories of the future.

That was the verdict from Dr James Fonda, an associate technical fellow with Boeing Research and Technology, speaking at the Factory 2050 Conference.

Dr Fonda told delegates that current IT systems often added to the workload of people on the factory floor and he warned that future developments would have to
be easier to use and bring visible benefits to the people using them.

Modern consumer technology was opening the way for mobile, wearable devices to be used on the shop floor, but they had to be easy to use and respond to the task involved.

“If you put a device on a person that is really hard to use, there is no business benefit,” said Dr Fonda.

Systems have to be able to work out what someone using a wearable device, or head-up display, need to see and display it, without the user having to search for the relevant information.

If wearable devices are being used to input data, their success depends on how well the users understand what the data means and where it is going. Developers of machine interfaces also needed to respond to the fact that new generations have grown up with computer systems that were capable of explaining how they work. Dr Fonda called for equipment developers to make their devices more compatible.

“We see a lot of different vendors with equipment that uses different data types and architectures. We build things out of all sorts of vendor technologies and systems and trying to integrate them is really difficult,” said Dr Fonda.

Difficulties were compounded for large companies that might have hundreds of different activities occurring in a production line at the same time. Sometimes, it was too difficult to integrate different systems, meaning data had to be replicated, which could lead to confusion over just which set of data was the master data. Large companies like Boeing needed software and networks that could easily be integrated and would not “take a lot of time to stitch together in house.”

Networks need to be agile and secure, and the security systems used by different components on the network needed to be standardised so that they could be made compatible with enterprise level IT systems. Security also had to be transparent to the user.

“It’s about getting agility into networking and moving data around. It’s about flexibility and really trying to make sure your factory is reconfigurable from an IT perspective, as well,” Dr Fonda concluded.
Natural way to design the factories of tomorrow

Istvan Nemeth, Budapest University of Technology and Economics

Researchers are borrowing from biology and philosophy as part of a European project to help small firms to rapidly design and evaluate new manufacturing systems.

The COPERNICO project, led by the AMRC involves five universities and research institutes, and 10 industrial and SME partners from across Europe.

Dr Istvan Nemeth, associate professor at Budapest University of Technology and Economics, said the COPERNICO group had adapted cladistics – the biological classification system – to create a library of factory equipment.

The group had also developed a way of defining the way equipment interrelated by developing ontologies – originally the philosophical study of the nature of beings – and created web-based tools that SMEs could use to explore different factory lay outs.

Adaptive automation will speed production and encourage better use of human capabilities

Dr Christian Hanisch (below), Festo and Darcie Cousins, Ubisense

Advances in manufacturing technology are opening the way for companies to make better use of the capabilities of their human workforce, creating sustainable social enterprises, according to Dr Christoph Hanisch, from automation experts Festo.

“It is possible that an engineer will develop a new product and, at the same time, design the manufacturing line, whilst, in the background the system creates a list of components necessary to build the appropriate machine,” Dr Hanisch told the Factory 2050 conference.

Moving from a hierarchical to an adaptive approach, where local modules can control and automatically change processes, could save system integrators months of work and allow production to be rapidly ramped up after a new line is installed.

“In future we will be able to cut the hierarchy and introduce information models,” said Dr Hanisch, whose interests include the effective design of research for future factories and strategies for strengthening manufacturing in Europe.

“New devices have more sensors, more control output that can be used in information models for different applications and different people.

“We have an opportunity to employ and use human capacities in a better way than we did in the past.”

However, Dr Hanisch also had concerns about the future.

“In manufacturing today, we talk about automation and dream of autonomous factories, but we don’t talk about people. We don’t talk about how they make a real living, care for their possessions and maintain a standard of living.

“We have a chance to change direction. We could use these technological developments to re-organise the shop floor and come to a new interaction with machines, using technology to design a sustainable social enterprise.”

Darcie Cousins from operational effectiveness and profitability specialist Ubisense, told the conference increasing automation and the data it generates could lay the foundations for the creation of “Learning Factories” that are able to anticipate and avoid problems automatically.

She said factories had already moved on apace from a time when manufacturing functions relied solely on human capabilities.

Today’s factories could use a high level of automation to feedback information that would lead to improved quality.

The next step would be the creation of a reactive or ‘learning’ factory that would collect context sensitive data and know the status of products and the devices used to make them all the time, even when they were moving.

In future, the ‘workspace’ would be fixed to the product, rather than the factory floor.

‘Learning Factories’ would anticipate and avoid problems by being sensitive to the rhythm of high volume, rapid, linear manufacturing processes, the pace of slower, leaner low volume processes and the sequence of events in non-linear, low volume processes, she added.

“Foundries of the future could cut defects by adopting the technology of today

Professor John Campbell

Professor John Campbell told the Factory 2050 Conference that metal was commonly poured at rates of round 2.5 metres a second – five times faster than it should be to avoid the creation of bifilms and bubbles that became entrainment defects.

“Cracks form first and inclusions form on them,” said Professor Campbell. “The crack was there first and the inclusion nucleates on the crack.

“Foundries use typical bucket technology. Pouring churns the metal up, gravity accelerates the metal to speeds you don’t want and puts energy in to create folding defects.”

Professor Campbell outlined how, when he worked for racing and high performance engine manufacturer Cosworth, he had introduced counter gravity castings technology that pumped molten metal into moulds.

As a result, the company was able...
to cast two cylinder blocks every 40 seconds and engine failures during testing were eliminated, after having previously been at 50 per cent. The introduction of a tower furnace had resulted in oxides from the outside of the molten metal remaining on the dry hearth, while inner ones sedimented out and the clean metal could be pumped upwards into the moulds.

The process had been cheap to install and resulted in a metal that was free from defects, would not fatigue or crack and reduced wear on machine tools. Professor Campbell highlighted the success of another ‘counter gravity’ casting system, the Griffin process, used to make railway wheels in the US, which was so reliable that only one casting in 10 million failed.

He also argued that the performance of single crystal castings had more to do with the fact that biofilms floated out or were pushed out during the slow solidification process than the single crystal structure.

“The metal is strong, not because it is a single crystal, but because it is pretty free from defects,” said Professor Campbell, adding that counter gravity casting could result in ten-fold improvements over conventional methods.

“People work their whole lives to get a 10 per cent benefit. Here, we are talking about 10 times the benefit – and it would be cheaper to make products without defects like this. We don’t have to wait until 2050 to do it. We could do it tomorrow,” he concluded.

### Machine manufacturer predicts fall in demand for raw materials and energy in the factories of the future

**Martin Werner (below), Hermle and Professor Lenny Koh, The University of Sheffield**

**Increased efficiency, the growth of monitoring technology and the combination of different manufacturing technologies will combine to reduce the demand for raw materials and energy in the factories of the future.**

Martin Wener, Key Account Manager with machine tool manufacturer Hermle, told the Factory 2050 conference there was big potential for improving the energy efficiency of factory machinery.

Mr Wener cited Hermle’s long experience of recovering energy from spindles under braking, its development of hybrid additive manufacturing and milling machines and self-checking machine tools as examples of how savings could be made.

Using soluble filler material with the hybrid machines, it was possible to create voids for cooling or heating elements by milling channels into components and depositing filler material in the channel, before adding a layer of metal on top.

Meanwhile, it was now possible to take an “electronic finger print” of machine tools leaving the Hermle factory.

“Every so often, the machine checks itself, sends the data to us and we can compare it with the original data so that we can carry out preventative maintenance, when necessary,” said Mr Wener.

“By 2050, consumption of resources will have decreased,” Martin Wener predicted.

“There will be a smaller number of machine operators, but they will be more like production supervisors and have a wider, more software related skills base. Machines will have the technology to monitor their own health and fine tune manufacturing to achieve the best possible tool life and results.

“There will still be a need for precision machining, but the volume of chips will reduce, due to additive manufacturing.”

Professor Lenny Koh told the conference that huge opportunities were opening up for companies large and small, as demand for secure energy supplies and reduced reliance on imports increase demand for increasingly localised supply chains.

Professor Koh, director of the Centre for Energy, Environment and Sustainability and the Logistics and Supply Chain Management Research Centre at the University of Sheffield, was speaking at the Factory 2050 Conference.

She said the drive for more sustainable growth had to include improving the capabilities of SMEs and supply chain efficiency, monetising the real value of resources.

Identifying carbon hot spots within companies and their supply chains was now possible thanks to the development of SCEnAT, the Supply Chain Environmental Analysis Tool, at Sheffield University Management School.

At the same time, concerns about some sectors’ increasing reliance on rare earth materials had led to initiatives such as the EPSRC-backed Critical Material Substitution Project designed to increase sustainability by identifying alternative materials.
Technology could allow builders to put up a house in a day and meet tough new targets

Stephen Harley, Laing O’Rourke

Advanced manufacturing could play a vital part in helping the UK’s construction industry meet challenging targets for new homes, according to Stephen Harley, from Laing O’Rourke.

Mr Harley told delegates to the Factory 2050 conference that, the proportion of people living in urban locations had risen from two in ten in the 1900s to five in ten today and is expected to increase further to seven in 10 by 2050.

Politicians were talking about the need to build 200,000 new homes a year, which would be a significant increase on the 140,000 homes that the industry was currently building.

“Our view of the speed of construction is that, if we keep doing what we are doing that number may increase a little,” said Mr Harley, Laing O’Rourke’s director for advanced manufacturing.

Achieving the sort of numbers politicians were seeking, while also responding to increasing demands from consumers for affordable homes which could be tailored to their personal choice would mean significantly changing the way the construction industry worked.

Laing O’Rourke plans to do that by increasing off site production and developing reconfigurable factories and automated assembly systems that can supply homes to construction sites as a set of modules. Advanced manufacturing techniques are already at play in the design of modern office blocks like the Leadenhall Building in the City of London – dubbed the London ‘Cheesegrater’ because of its appearance. Virtual reality versions of the Cheesegrater had been built 31 times before physical work began. It was now possible to capture data for living conditions, modify designs accordingly and create strategies for preventative maintenance before a building was constructed.

There would come a time in the not too distant future when 90 per cent of construction would be “completed off site, in a clean, safe factory environment,” said Mr Harley. By incorporating “Plug and Play” connections for mechanical and electrical services, Laing O’Rourke believes that once site work is complete, a typical house could be built and ready for occupation within a day.

Meanwhile, zero carbon rated apartments could be constructed one floor a day, with a typical block being ready for occupation in a week. The AMRC will be playing its part in that revolution by spearheading a £1.6 million research project, which is part of a £104 million programme, launched by Laing O’Rourke and backed by a £22.1 million grant from the Department for Business Innovation and Skills.

It will develop advanced ways of making modular systems for new homes, other buildings and their supporting infrastructure; investigating the automated assembly of mechanical and electrical services for buildings.

Meanwhile, the AMRC Training Centre will identify training needs, develop accredited programmes and provide training for workers using the new technologies and techniques the AMRC develops.

Laing O’Rourke reckons that as many as 600 new, direct jobs could be created by its programme and a further 1,000 in its diverse supply chain.

Robots and other flexible, advanced manufacturing technologies will be harnessed as part of the programme, but Laing O’Rourke’s ambitions don’t end there. Stephen Harley sees a day when robots will also be used on building sites, but he told the Factory 2050 Conference they would need to be able to work safely with humans who will provide the dexterity needed to modify, fit out and finish the homes of the future.

Robots and other flexible, advanced manufacturing technologies will be harnessed as part of the programme, but Laing O’Rourke’s ambitions don’t end there. Stephen Harley sees a day when robots will also be used on building sites, but he told the Factory 2050 Conference they would need to be able to work safely with humans who will provide the dexterity needed to modify, fit out and finish the homes of the future.

Digital natives will engineer tomorrow’s factories with surgical precision

Tom Newman, Meggitt, Dr Mark Robinson & Dr Gail Clarkson, The University of Leeds, Dr Dermot Breslin, The University of Sheffield

Tomorrow’s factory workers will need to be more like today’s surgeons, following procedures, but able to use their knowledge to adapt to new circumstances, with equipment like intelligent workbenches as their assistants, according to Tom Newman.

Mr Newman, from FTSE 100 global engineering group Meggitt, said technological advances and automation would not replace workers in the factories of 2050, or turn them into simple machine minders, but tomorrow’s factory workers would expect to work differently.

People born after the millennium were “digital natives” who didn’t just consume content, but socialised, learnt and challenged each other.
“People are going to expect to work differently. They are not going to expect linear procedures and manuals to guide them through their work,” said Mr Newman.

Organisational psychologist Dr Mark Robinson, from the University of Leeds, told the Factory 2050 Conference that innovation in processes and improvements in management procedures and communication would be increasingly important in the factories of the future. As current systems became automated the workforce of the future would need to be more skilled and competition for the best employees would increase, said Dr Robinson.

Colleague Dr Gail Clarkson emphasised the links between altruistic behaviour within teams and their success, while Dr Dermot Breslin, from the University of Sheffield Management School, highlighted when groups undertook breaks to perform undemanding tasks, this improved their problem solving performance.

Dr Clarkson suggested manufacturing could benefit from the lessons of biological evolution.

“People are going to expect to work differently. They are not going to expect linear procedures and manuals to guide them through their work,” said Mr Newman.

Organisational psychologist Dr Mark Robinson, from the University of Leeds, told the Factory 2050 Conference that innovation in processes and improvements in management procedures and communication would be increasingly important in the factories of the future. As current systems became automated the workforce of the future would need to be more skilled and competition for the best employees would increase, said Dr Robinson.

Colleague Dr Gail Clarkson emphasised the links between altruistic behaviour within teams and their success, while Dr Dermot Breslin, from the University of Sheffield Management School, highlighted when groups undertook breaks to perform undemanding tasks, this improved their problem solving performance.

Dr Clarkson suggested manufacturing could benefit from the lessons of biological evolution.

“People are going to expect to work differently. They are not going to expect linear procedures and manuals to guide them through their work,” said Mr Newman.

Organisational psychologist Dr Mark Robinson, from the University of Leeds, told the Factory 2050 Conference that innovation in processes and improvements in management procedures and communication would be increasingly important in the factories of the future. As current systems became automated the workforce of the future would need to be more skilled and competition for the best employees would increase, said Dr Robinson.

Colleague Dr Gail Clarkson emphasised the links between altruistic behaviour within teams and their success, while Dr Dermot Breslin, from the University of Sheffield Management School, highlighted when groups undertook breaks to perform undemanding tasks, this improved their problem solving performance.

Dr Clarkson suggested manufacturing could benefit from the lessons of biological evolution.

“People are going to expect to work differently. They are not going to expect linear procedures and manuals to guide them through their work,” said Mr Newman.

Organisational psychologist Dr Mark Robinson, from the University of Leeds, told the Factory 2050 Conference that innovation in processes and improvements in management procedures and communication would be increasingly important in the factories of the future. As current systems became automated the workforce of the future would need to be more skilled and competition for the best employees would increase, said Dr Robinson.

Colleague Dr Gail Clarkson emphasised the links between altruistic behaviour within teams and their success, while Dr Dermot Breslin, from the University of Sheffield Management School, highlighted when groups undertook breaks to perform undemanding tasks, this improved their problem solving performance.

Dr Clarkson suggested manufacturing could benefit from the lessons of biological evolution.
Evolution could power a revolution in machine adaptability for manufacturing in the future

Dr Jack Chaplin, The University of Nottingham and David Brown, Hexagon Metrology

Manufacturing systems that can evolve and adapt to change could become a reality in tomorrow’s factories thanks to a £2.6 million research programme.

Delegates to the Factory 2050 conference heard Dr Jack Chaplin from the University of Nottingham’s Manufacturing and Process Technologies Research Division outline work on the development of ‘Plug and Produce’ machines.

The machines are being developed as part of an Engineering and Physical Sciences Research Council (EPSRC) project.

Each machine has £30 Raspberry Pi Model 2 computer embedded, allowing it to be plugged in and out of a production process which then modifies itself to take account of the change in resources.

“No single agent is in control, all are sharing responsibility,” Dr Chaplin explained. “If you plug something in, it announces itself to the system, thinks for itself and talks to its neighbour.”

With ‘Plug and Produce’, it should be possible to add new pieces of equipment to the process without having to reconfigure the manufacturing system. Similarly, if a piece of equipment breaks down or has a problem, the system should reconfigure itself so that it can keep manufacturing.

The Nottingham team is developing three demonstrators as part of the programme. One is designed to assemble hinges for car doors, another is going to simulate a plant making customisable pharmaceuticals and the third, called the Future Automated Aerospace Assembly Demonstrator, could build flaps for aircraft wings.

Hexagon Metrology UK’s director and general manager, David Brown told the conference that automation had become a key driver for metrology, which was rapidly transforming into an IT business.

“We don’t see ourselves as metrologists. We are an IT company,” said Mr Brown.

“Metrology has evolved into an IT world. We capture data, analyse and present it; providing information the world can react to. Automation is a key driver.”

Internet of Things offers major productivity benefits for companies with compatible data

Richard Allan, PTC and Martin Kelman, ATS Global

With more devices now connected to the internet than people on the planet, new opportunities are opening up for significant productivity savings, according to Richard Allan senior regional sales director for the UK, Belgium and the Netherlands at PTC.

PTC specialises in computer aided design, product, application and lifecycle management and the Internet of Things (IoT). It recently acquired Axeda, which provides advanced cloud-based services and software for managing connected products and machines and implementing Machine-to-Machine (M2M) and IoT applications.

PTC also owns ThingWorx, the first IoT platform designed to build and run the applications of the connected world. Richard Allan told delegates to the Factory 2050 conference how one customer who manufactures milking machines, was responding to demand by enabling its machines to collect data on local weather conditions and when individual cows were ready to be milked.

Enterprise systems were available that could collect data from multiple plants, but in many cases, plants operated as isolated silos, with applications that used non-standard Key Performance Indicators, which meant the information could not be used productively.

“There are good systems that provide good information and can have an impact on the process, but they are all very disparate and only five per cent of the information can be found, so how can it be used?” said Richard Allan.

“IT systems have to be as flexible as the manufacturing systems they are supporting. We need to drive forward IT to meet the demands of the manufacturing we have today,” Martin Kelman concluded.

“There is little use in getting reams of reports about things that have already happened – it’s too late.”

Martin Kelman, from industrial and process automation specialist ATS Global, told the conference that new standards that enable off the shelf products to work cooperatively were among the advances needed to allow companies to reap major benefits from future automation.

Information Technology needed to be as flexible as the manufacturing systems it supports, said Mr Kelman. IT policies were hampering shop floor operational technology (OT) as a result of the trend towards locating IT resources in remote data centres.

“OT is all about automation. IT policies prevent OT from working,” said Martin Kelman.

Most factories brought together a range of stand-alone equipment with no standard means of communicating, which meant they had to be “mashed together in quite a complicated way.”

A single factory could use 50 to 100 separate technologies to control everything. Ideally, what was needed was a single portal that was not application specific and could be used to share information within an enterprise and connect to the supply chain.

Research centres could help to drive forward standards that would allow ‘Plug and Play’ machinery and automation to be developed.

“The future for manufacturing is to be as flexible as the manufacturing systems they are supporting. We need to drive forward IT to meet the demands of the manufacturing we have today,” Martin Kelman concluded.
Researchers from the University of Warwick are looking for ways to enable designers to understand the impact their decisions will have on the cost of a finished product.

Ken Asare, from the University of Warwick, told delegates to the Factory 2050 Conference that typically, costs were mainly worked out by a company’s finance department when the product was ready to go to market.

However, moves to develop cost and resource databases could mean that, in future, designers will have control over the cost of what they are designing.

Meanwhile Claire Jevons, from the Industrial Doctorate Centre at the AMRC outlined attempts being made to create a framework for modelling costs that would help to understand the drivers and predict future changes so that it would become easier to quantify the impact of emerging new technologies.

Ken Asare and Claire Jevons were among a number of researchers delivering quick fire presentations of new research during the Conference. Delegates also heard how attempts were being made to assess the sharpness of tools using high resolution 3D scans.

The research had already shown that ground tools were blunter than pressed tools, after carrying out the same cutting strategy.

Further research was being carried out to investigate errors and the source of errors in robot milling, comparing the results of finite element analysis and the results of cutting wear measurements.

Dr Hatim Laalej, from the AMRC with Boeing, outlined research into the measurement of temperature in machining, using a thermal camera and thermocouples 1.5mm from the cutting edge. Trials showed that results were repeatable and the response time from the thermal camera was far superior.

Further work on improved sensing and measurement without having to take a component off a machine, whilst also collecting tool and machine performance data was explained by AMRC technology fellow Tom McLeay.

**UK manufacturers must invest to reap the benefits technology offers for a radical rise in productivity**

*Brian Holliday, Siemens*

Manufacturing could be on the cusp of a radical increase in productivity, but the UK risks being left behind because it is still chronically under investing in technology, according to Brian Holliday, from Siemens.

Mr Holliday, managing director for Siemens Digital factory Division in the UK, Ireland, Nigeria and Ghana was delivering the opening address at the Factory 2050 conference, organised by the AMRC. He told the 200 delegates that many of the technologies that would feature in Factory 2050 were in use today.

“What we need to do is to apply them. We have a job to do to show what is possible today,” said Mr Holliday. Research showed that UK manufacturing could increase productivity by more than 27 per cent and employment by seven per cent if companies followed the lead of the world’s leading automators.

Manufacturing was entering a fourth industrial revolution. Following on from the creation of the loom, the diversification of labour and electrification and robotics and automation, the latest revolution would be characterised by ‘autonomous automation.’

The latest revolution was being driven by a number of factors, said Mr Holliday. Energy shortages and rising costs had increased the competitiveness.

Meanwhile, consumers were becoming increasingly demanding and the pressure was on to significantly reduce the time needed to get products to market.

Tomorrow’s factories would have to integrate software and design capabilities with the flexibility to be able to make a wider range of products in the same plant.

“Manufacturers need to design quicker, make quicker and ship quicker. We are also seeing demand for the internet to be built in to products,” said Mr Holliday, adding: “We have got to find ways to become more flexible because, increasingly, as consumers we want more tailored products.”

Increasing use of off the shelf technology and consolidation of standards was allowing companies to collaborate more easily and the ‘industrialisation’ of IT meant the price to enter the technology market was dropping.

Software and technology capabilities were no longer a constraint, but there were still challenges to be faced – not least in ensuring safety and security as demand for remote access and control to plant operations increased.

There was also a need to connect to the supply chain.

“If we believe the future involves making smart products in smart factories, we need to consider the smart supply chains to which producers will need to connect,” said Mr Holliday.
Cyber threats rise as more machines are plugged in to the Internet of Things

Stephen Hailes, UCL

One in three manufacturers have faced a directed cyber attack during the last year and the number of vulnerabilities is growing, according to Professor Stephen Hailes, from the Department of Computer Science at University College London.

Professor Hailes warned delegates at the Factory 2050 conference that people had felt secure in the past because they believed equipment wasn’t plugged into a network or it was on a network that was secure from attack.

However, people were increasingly plugging equipment into the Internet without realising it – to such an extent that there were now a number of companies with industrial control systems that were known to be insecure and infected because the cost of taking the system down was too high.

Professor Hailes said the number of internet connected devices was high and projected to rise, meanwhile, the number of “zero day vulnerabilities” – flaws in software, hardware or firmware that are exploited before or as they become generally known – was also growing.

Just over one in four cyber attacks are targeted at industry and both the motivation for attacks on industrial control systems and the methods used are different to other attacks, with attackers having specific targets and objectives.

Attacks had ranged from a disgruntled employee who caused a major sewage leak and a targeted attack which caused serious damage at a German steel plant to the Stuxnet attack against Windows computers and Siemens control systems, which Professor Hailes described as “an act of cyber warfare.”

Professor Hailes warned that relying on data encryption or thinking that security could be ‘bolted on’ to systems would not work.

“Security isn’t a technology you buy. It’s something you do,” said Professor Hailes.

“We aren’t actively identifying threats. We need to be pro-active and find out how people are going to attack systems by attacking these systems ourselves.

“We need collaboration between industry and researchers and we need, as researchers, exposure to real systems.”

Professor Hailes also called for companies hit by cyber attacks to be more willing to talk about what had happened. “Sharing information about incidents is really important,” he said.

Additive manufacturing offers new options for personalisation and reduced costs

Neil Hopkinson, The University of Sheffield

New developments in additive manufacturing (AM) technology could help to satisfy rising demand for personalisation and open the way for products with electrical components that have been printed inside.

Neil Hopkinson, Professor of manufacturing engineering at the University of Sheffield and director of its Centre for Advanced Additive Manufacturing (AdAM), told the Factory 2050 Conference that AM was already being used to make bespoke hearing aids.

Investigations were also underway that could lead to the development of bespoke running shoes for elite athletes and then on to personalised sports footwear for the consumer market.
Predictive manufacturing will cut new production line costs and improve quality

Researchers from the University of Warwick are using data and knowledge collected from existing production systems to help recognise patterns indicating the potential performance of new systems. They hope their research into what they describe as ‘Predictive Manufacturing’ will result in closer integration of product and manufacturing system design, quality improvements and reduced lifecycle costs.

Dr Kobby Kodua, from the Warwick Manufacturing Group’s Digital Lifecycle Management Research Group, says manufacturers have a tendency to start from scratch every time they design a manufacturing system.

"Systems change, but you can detect a pattern or logic behind what is happening," Dr Kodua told the Factory 2050 conference.

Classifying manufacturing systems, creating a database of systems and collecting live data from those systems could help to predict what would happen if the system was reorganised.

The Warwick researchers have been testing out their theories by trying to develop a production system for remote laser welding two sheets of metal that might replace a spot welding line, reducing costs by 35 per cent in the process.

Manufacturers in the UK need to invest more heavily in integrated equipment if they are to improve productivity, Ernst Wagner, managing director of KASTO UK, the metal sawing and storage systems specialist told the Factory 2050 Conference.

Mr Wagner said the UK was quite active when it came to making investments, but commonly the investment was in standalone equipment.

Citing KASTO’s own experience as evidence, Mr Wagner said that of the 1,350 saws it had at plants in the UK, not one was part of an integrated “store to floor” solution, linking warehousing automatically with processing, marking palletising and the like.
Subsea oil and gas production may slow, but there will still be plenty of opportunities to win business – and not necessarily at the lowest price.

John Duffy, from Vulcan SFM, the world leading supplier of large castings and forgings to the oil and gas sector, told the NAMTEC oil and gas supply chain conference that a supplier offering better lead times could often beat one with a lower price. He advised companies seeking to supply the sector, to develop a reputation for quality and safety, which also encompassed their sub-contractors.

They also had to offer top quality reporting and regular updates, keep their scheduling promises and ensure they could produce detailed documentation before, during and after carrying out the contract.

Opportunities include making forgings, castings and fabrications, supplying materials, flanges and fasteners, welding services and supplies, providing coating and painting services and carrying out inspection and testing. Mr Duffy also urged companies not to focus solely on the North Sea, he said:

“The offshore subsea market is a truly global market.”

“Most of our business comes from the Gulf of Mexico and Malaysia. If you are interested in the market, don’t just look at the North Sea.”

He also urged companies to be bold and innovative.

“Be bold enough to question why some things are specified, if the project is asking for material properties that are completely unrealistic.

“There is broad scope for innovation, new products and services,” he added.

David Thompson, from compliance, risk and technical consultancy Lloyds Register, warned that the sector supply chain could be complex and opportunities to extend lists of suppliers could be restricted by the cost of audits and fears over the risk a new, unproven supplier could pose to a business.

He predicted that there could be an increase in requirements for third part inspection in the European market, including joint inspections involving end users and manufacturers, starting at the materials approval stage.

David Thompson said there could also be a move towards independent, third part inspection in the US, where most auditing was currently carried out internally or by sub-contractors.
Opportunities in Oil and Gas

Future secure for oil and gas despite dramatic fall in the oil price

According to Adam Davey, economics and market intelligence Manager for the UK offshore oil and gas industry’s leading representative body, Oil & Gas UK.

However, pressure to reduce costs will remain high, despite hopes the oil price will recover, Mr Davey told a well-attended conference on supply chain opportunities in oil and gas, organised by NAMTEC.

Mr Davey said 57 per cent of the world’s energy currently comes from oil and gas and the proportion would still be 55 per cent in 20 years time.

The unusually strong rise in US production, due to fracking, was likely to continue, but there were signs that people now believed the oil price would recover to $70 to $80 a barrel in the next few years, while Shell’s bid to buy gas exploration and production company, BG Group, implied a $90 price.

However, UK operating costs per barrel had more than doubled recently, making the UK the most expensive place to operate.

“We have seen absolutely rampant growth in the cost of operations in the UK, against a declining production base, with companies paying 40 to 50 per cent more to operate 40 to 50 per cent less production than 10 years ago,” said Mr Davey.

“Cost control and efficiency are absolutely vital. Asset stewardship and production performance needs to be improved.”

Companies were still investing in looking for, and developing, new oil and gas reserves and around a third of the reserves under the UK continental shelf were still to be extracted.

Now was the perfect time for companies with big balance sheets to explore, however, in many cases it was far easier to invest in improving the performance of existing assets than to exploit new ones.

Energy sector poses new challenges for established and innovative materials

According to Alastair Lang, business development manager for the Materials Processing Institute, told the conference that opportunities existed in Carbon Capture and Storage (CCS) and the oil and gas sector for companies that could develop lower cost, lower grade materials, with properties similar to higher grade materials.

High strength, corrosion resistant, special materials were increasingly in demand for use in sour wells, where hydrogen sulphide could cause hydrogen embrittlement, and wells where sand extracted with the oil and gas caused erosion.

Exploration in ever deeper waters is also leading to demand for materials capable of withstanding high temperatures and pressures, while new steels are needed to increase the life of components used in fracking, where the nature of the material being extracted meant pump parts currently needed to be replaced every few weeks.

Mr Lang said there were opportunities to supply materials and components for a range of CCS systems.

These included CCS absorbers, which capture CO2 in flue gasses in a solvent, and desorbers, which separate the solvent out, so that the gas can be compressed.

There were also opportunities to supply pipeline materials, which would need to be able to withstand the high temperatures and pressures the CO2 would be subjected to in order to increase its density and allow the pipelines to work as efficiently as possible.
Power station project offers openings for oil and gas sector suppliers

The 448MW plant will be the UK’s first coal-fired CCS power station and will have the capacity to supply enough electricity for 630,000 homes.

Pulverised coal will be fed into the plant’s boiler, along with oxygen separated from the atmosphere, to produce flue gases rich in CO₂, which will be cleaned and fed back into the boiler. Highly purified CO₂, separated from the flue gases, will be compressed and transported by pipeline and stored in an aquifer beneath the North Sea.

Around two million tonnes of CO₂ – about 90 per cent of the CO₂ produced by the plant – will be captured and the plant could become a zero emitter of CO₂ if biogas was used instead of coal, Dr Jim Doyle, Environmental Consents Officer for Drax Power, told the NAMTEC conference on supply chain opportunities in oil and gas.

Dr Doyle said the project aimed to demonstrate that Oxyfuel Carbon Capture and Storage was a reliable, flexible and competitively priced low carbon technology, which improved the UK’s security of energy supplies and could act as an anchor project for transporting and storing CO₂.

The pipeline, operated by National Grid, would have the capacity to carry 17 million tonnes of CO₂ a year, which meant there would be 15 million tonnes of excess capacity, which could be used by other companies to reduce their CO₂ emissions.

Outlining opportunities for suppliers, Dr Doyle said: “We have a lot of expertise locally in power generation, maintenance and power station construction.

“We have expertise here to deal with large projects and, if we can make projects like this a success, I see no reason why we cannot be a world leader in CCS technology.”

Dr Doyle said the Drax project would need 20,000 tonnes of metal alone and there could be opportunities to retrofit the technology developed at Drax to other power stations, build new Oxyfuel CCS power plants and export the technology worldwide.

Materials for Manufacturing – Sheffield: the Sir Henry Royce Institute and the Innovation District

New Institute will cut the time taken to commercialise new materials

Professor Colin Bailey, University of Manchester

World leading UK research centres are aiming to radically reduce the time it takes to get new materials to market.

That is one of the targets for the new Sir Henry Royce Materials Institute business leaders heard when they attended a conference on plans for the Institute’s development at the AMRC with Boeing.

A total of £235 million is set to be invested in the new Institute, which will be based at the University of Manchester.

The Institute will carry out research aimed at developing new materials that will help industry cut its costs and consumption of energy and raw materials at the Universities of Sheffield, Leeds, Liverpool, Oxford, Cambridge, Imperial College, as well as Manchester.

It will also work with the National Nuclear Laboratory and Culham Centre for Fusion Energy.

“Advanced materials underpin all our industrial sectors. If we could take advanced materials to the market more quickly we could have a significant impact on UK plc,” said Professor Bailey.

“Getting materials to market can often take more than 20 years, we know that we can halve that with the UK’s expertise in materials research.”
However, what was missing was a facility to design and test new materials and accelerate these getting to market. This is what the Royce Institute will do."

Professor Bailey said the new Institute would be a national body, bringing together a network for individual research centres and the Catapults, set up by government to help companies of all sizes develop new technologies for commercial use.

Its creation had been incorporated in the UK Science and Innovation Strategy, with work on the business case for its creation and how it would be governed currently underway with the Department for Business Innovation and Skills.

Once it was established, the Institute would focus on accelerating the use of advanced materials for engineering and energy extraction and production, ‘functional’ materials; including graphene, nano materials, materials used in the IT sector and ‘soft’ materials, including bio materials and ‘smart’ coatings.

The institute will not only focus on developing new materials, it will also look at ways of improving the performance of existing materials.

Research into high performance materials and powders promise significant benefits, says industry

Neil Glover, Rolls-Royce and Dan Johns, GKN Aerospace

Potential beneficiaries from the work of the Sir Henry Royce Materials Institute have emphasised the importance of its plans to develop new, high performance materials and improved metallic powders for additive manufacturing

Neil Glover, head of materials at Rolls-Royce said aerospace customers wanted future aero engines with reduced environmental impact and better performance.

That meant Rolls-Royce needed higher strength, higher temperature, lower density materials that offered the same high levels of safety as the current materials in use at the lowest possible cost.

“We need them as quickly as possible and we need to be able to predict what they will do in service,” said Mr Glover. Rolls-Royce believed powder technology having an increasing part to play in repairing extremely high value aero engine components which occasionally suffered damage when sand, grit or even stones were sucked in.

However, research was needed to ensure the techniques used produced a repair with the right microstructure, geometry and performance," said Mr Glover.

Dan Johns, chief technologist for GKN Aerospace, said the additive manufacturing technology to make aerospace components was there, the question was how to scale it up for industrial production and meet the qualification requirements for aerospace.

One answer was to redesign existing components for additive manufacturing and save on materials.

“A one kilogramme titanium component, machined from billet, requires 26 tonnes of rocks at the mining end. That same part made by additive manufacturing requires nine tonnes of rocks,” said Mr Johns, a visiting Professor of Advanced Material Processing at the University of Sheffield.

"With additive manufacturing, you can move to a more organic topology, you can reduce material waste, be more efficient and win more orders," he added, citing as an example another component which had been made as a near net shape forging.

When produced by additive manufacturing the component had required five times less raw material and finish machining had generated 13 times less swarf than the forging.

"A one kilogramme titanium component, machined from billet, requires 26 tonnes of rocks at the mining end. That same part made by additive manufacturing requires nine tonnes of rocks," said Mr Johns, a visiting Professor of Advanced Material Processing at the University of Sheffield.

"With additive manufacturing, you can move to a more organic topology, you can reduce material waste, be more efficient and win more orders," he added, citing as an example another component which had been made as a near net shape forging.

When produced by additive manufacturing the component had required five times less raw material and finish machining had generated 13 times less swarf than the forging.

"A one kilogramme titanium component, machined from billet, requires 26 tonnes of rocks at the mining end. That same part made by additive manufacturing requires nine tonnes of rocks," said Mr Johns, a visiting Professor of Advanced Material Processing at the University of Sheffield.

"With additive manufacturing, you can move to a more organic topology, you can reduce material waste, be more efficient and win more orders," he added, citing as an example another component which had been made as a near net shape forging.

When produced by additive manufacturing the component had required five times less raw material and finish machining had generated 13 times less swarf than the forging.

“With additive manufacturing, you can move to a more organic topology, you can reduce material waste, be more efficient and win more orders,” he added, citing as an example another component which had been made as a near net shape forging.

When produced by additive manufacturing the component had required five times less raw material and finish machining had generated 13 times less swarf than the forging.

When produced by additive manufacturing the component had required five times less raw material and finish machining had generated 13 times less swarf than the forging.
Materials for Manufacturing – Sheffield: the Sir Henry Royce Institute and the Innovation District

Materials design brings dramatic improvements to the performance of steel

Mark Rainforth and Ian Todd, University of Sheffield (below) and James Hughes, AMRC-NAMTEC

New materials, designed from first principles, using computer simulation, while the techniques for processing them are developed in parallel before any of the material has been produced and high strength steels that can easily be formed could be closer to reality than you think.

University of Sheffield Professors Mark Rainforth and Iain Todd outlined some of the current research developments which could lay the foundations for future initiatives involving the Sir Henry Royce Materials Institute.

They highlighted the work of the Designing Alloys for Resource Efficiency Project (DARE), which involves the Universities of Sheffield, Cambridge and Imperial College, and focuses on the concurrent design of materials and process routes.

Professor Rainforth outlined the development by Tata of a new, light weight, high strength steel, which was still formable and is intended for vehicle chassis.

“We have seen dramatic changes in steel through materials design,” said Professor Rainforth.

Meanwhile, a new approach involving work on both material chemistry and process routes was aiming to produce new metals that were more resistant to hydrogen embrittlement.

Professor Todd told the conference there was a huge push for novel metals discovery around the world.

Dr James Hughes, director of AMRC-NAMTEC, stressed the importance of collaboration between researchers, engineers and industrial partners and the availability of state of the art facilities.

The translational research which the new Institute would carry out to take new technological developments through to proving and pre-production would need to result in a two or three fold improvement, in order to demonstrate a business case for their introduction, he said.

Investment will make sure tomorrow’s innovative materials are industry ready

Richard Jones, The University of Sheffield

Development of new materials that will cut energy and raw material costs and that are ready to go straight into use in industry is set to accelerate thanks to what could be a £30 million investment in advanced manufacturing research in the Sheffield region.

University of Sheffield Pro-Vice-Chancellor for Research and Innovation, Professor Richard Jones, told Sir Henry Royce Materials Institute conference delegates that a new centre for the Institute would be built close to the AMRC and its new Factory 2050 development.

Prof Jones said: “We anticipate a physical facility involving about £30 million worth of investment, which will happen right here in what we are starting to call the Sheffield Advanced Manufacturing Innovation District, right next to the AMRC and close to Factory 2050.”

Urging businesses to make full use of the new Institute’s capabilities, Professor Jones added: “This is already an internationally significant centre for transformational engineering research.

“We have very ambitious plans to take this transformation further. We would really like you to be part of this fantastic innovation campus that we have here.”

Work at Sheffield will focus on the development of powder metallurgy, including improving the quality of powders – a factor which another speaker, Neil Glover, from Rolls-Royce, said had a crucial impact on the service life of aero engine components.

The Sheffield facility will also specialise in developing new, high strength, low weight materials and the techniques manufacturers will need to make components from those materials.

Prof Jones and Mr Glover, who is responsible for Rolls-Royce’s materials engineering research and development programme, were among a number of speakers who emphasised the need to consider manufacturability when developing new materials.

“It’s great to have new materials but we have to put together processes to exploit those if they are to be manufacturable at scale,” said Prof Jones. “We want to help to create new materials, new processes and new products that will give you, as companies, a competitive edge and help our region to generate the exports we need.”

Neil Glover told the conference that one of the reasons research was of vital importance to Rolls-Royce was because the majority of its £73.7 billion order book was for products that are still being developed.

With 48 per cent of its income generated by providing services, the global aerospace and marine and industrial power systems supplier needs new technologies not simply to make engines but to service and maintain them throughout their lifetime.

“We spend £1.2 billion a year on research and development, made 600 patent applications in 2014 and work with 31 university technology centres worldwide,” Rolls-Royce’s Neil Glover told delegates to the Sir Henry Royce Materials Institute conference.

“We don’t do research in university centres because we think it is interesting or because we think it is fun. We do it because we need it.”

Titanium turbine blade manufactured by selective laser melting

housing.com
Case study

Oil and gas sector materials specialist acts to cut energy consumption

Howco: A leading global processor and supplier of specialist materials for the oil and gas sector is showing its commitment to reducing environmental impact by cutting greenhouse gas emissions and the amount of energy it uses.

Howco Group processes and supplies materials including nickel alloy, duplex, stainless and low alloy steel used to make components for critical applications, such as subsea well heads, down hole and surface drilling and oil and gas production equipment.

The growing Glasgow-based group has facilities in the USA, Canada, Norway, Singapore, Malaysia, China and Dubai, as well as the UK, and is exploring opportunities for introducing new products and services.

Howco is also a major energy user, spending more than £1.5 million on energy a year.

Generating the energy it consumes produces greenhouse gas emissions equivalent to 10,000 tonnes of CO₂ over the same period.

The group is committed to continually reducing its environmental impact is at the core of its business.

To help it achieve that aim and limit the effect of energy cost increases in the future, Howco sought support from NAMTEC and its ERDF financed Direct Company Support Scheme.

NAMTEC appointed consultants E9 to help the group to roll out a programme of energy measurement, monitoring and management that would enable it to achieve the international Energy Management Systems standard, ISO50001:2011.

Howco’s European Operations Director, Andrew Marwood, said: “As market leader in the industry we are constantly striving to improve the company and its effects on the environment.

“The funding and assistance from E9 has put us in an excellent position to ensure the focus and management structure is in place at each of our 5 European sites, enabling us to achieve ISO 50001 accreditation during 2015.”

E9 helped Howco to use a range of techniques, including thermal imaging, metering and data logging, to monitor plant and equipment, assess energy demand, create a breakdown of energy use at its sites and develop Energy Performance Indicators.

The consultants worked with Howco to set up energy committees and teams and identify opportunities for energy reduction, better management and monitoring; set energy management objectives and timescales and identify the resources needed to achieve them.

The consultants also helped Howco develop a framework for its ISO50001 energy management system using Evolve software from E9, worked with Howco to implement the necessary processes and procedures and trained staff who would be responsible for the system, in addition to implementing the auditing process.
Upcoming courses

JUNE

15th: Stainless Steel Metallurgy
Aberdeen
A one day technical course covering all aspects of the production and use of a range of stainless steel alloys.

16th: Combating Corrosion
Aberdeen
The course aims to provide delegates with a full understanding of the principles of metallic corrosion and prevention mechanisms appropriate to a variety of applications.

17th: Nickel Metallurgy
Aberdeen
The course aims to provide learners with a sound understanding of the different characteristics of a wide range of nickel alloys, the fabrication of nickel components and the service condition to which they are suited.

18th: Metallurgical Failure Analysis & Prevention
Aberdeen
This course will enable delegates to determine how and why a metal component has failed or fractured during service and identify means of detecting and preventing such failures in the future.

18th: Apprentice Mentoring: Engineering the Next Generation
AMRC Training Centre, Rotherham
This programme will provide an understanding of what is included within the mentoring process for businesses employing apprentices. It will cover attributes required, the mentoring process and how to work with assessors.

22nd-25th: Advanced CNC Milling Programme
AMRC Training Centre, Rotherham
A four-day course exploiting the use of CAD/CAM for 3D CNC milling processes. Explore advanced cutting strategies employed by CAM systems. This is a practical “hands on” course with machining & computer activities.

25th: Fundamentals of Metallurgy
Macaw, Tyneside
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.

JULY

1st: Metals Technology Certificate
Various locations
“METTECH” is a coordinated programme of training courses intended primarily for technical staff who are routinely involved in the processing or testing of metals-based products. It is also suitable as technical background for staff in engineering and commercial functions.

7th: Introduction to Machining
AMRC Training Centre, Rotherham
This one day course provides an overview of the wide variety of machining technologies available for cutting and forming shapes from metal feedstock. It provides a wide-ranging account of the characteristics, advantages and limitations of traditional and advanced techniques.

13th-16th: IOSH Managing Safely
AMRC Training Centre, Rotherham
This four day course is intended to increase the health and safety management skills of managers and supervisors across your business. This nationally recognised and respected certificated training for managers and supervisors has been designed, and is quality-controlled, by the chartered body for health and safety professionals IOSH.

20th-23rd: Intermediate CNC Turning Programme
AMRC Training Centre, Rotherham
A four-day intermediate course giving a more in depth view of CNC lathe-work, and typical applications in today’s modern engineering environment.

BOOK NOW!