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How floating turbines
could reshape
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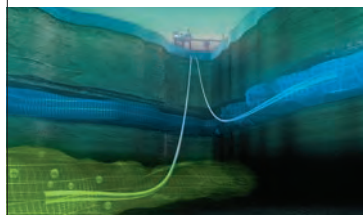
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Careers feature

Why the UK rail industry is
the perfect springboard to an
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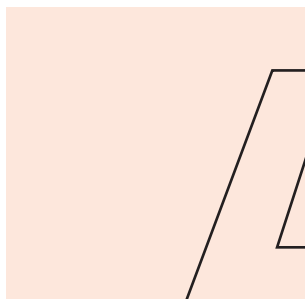
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our opinion

Making new friends



s nuclear new-build gets back on track; pressure mounts to kick-start a domestic shale gas industry; and the government appoints an energy minister – Andrea Leadsom – who once called for cuts to wind-farm subsidies, the UK's renewables sector is badly in need of some friends at the moment.

And this issue's cover story (p22), which looks at the emerging field of floating offshore wind power, is a reminder of why the sector deserves support.

Floating wind, which enables turbines to be tethered to the seabed, promises to help overcome some of the key challenges facing the sector. Far out to sea in deep water traditionally off limits to turbines, the winds are stronger and more predictable. Tapping into this resource could be a game-changer for offshore renewables. Few in the sector dispute its potential, but government support is essential to take it to the next level.

Another area of energy policy that's fallen off the government's radar is carbon capture and storage (CCS). Prof Michael Stephenson, director of science and technology at the British Geological Survey (p30), describes the government's cancellation of the UK's £1bn CCS competition as "catastrophic" and calls on big business to throw its support behind a technology that many believe will be critical if we are to meet our emissions targets.

"Floating wind power is a reminder of why renewables deserve support"

Elsewhere in this issue we turn our attention to a familiar issue – women in engineering – and look to what some might regard as an unlikely champion of diversity and equality: the Muslim world. As our report reveals (p44), while the UK still struggles to increase representation of women in engineering beyond 9 per cent, female engineers make up a preconception-busting 60 per cent of the workforce in some predominantly Muslim countries.

The reasons for this are complex. But one explanation is that Islam's emphasis on shared social responsibility makes engineering an obvious career choice. If there's a lesson here for the UK, it's perhaps that we need to work harder to stress the role that engineers play in addressing some of society's most pressing problems.

If you want to see some great examples of how engineers make the world a better place, register now for our Collaborate to Innovate conference, happening in Coventry on 17 November. Turn to p52 to find out more. ©

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DEFENCE

Keeping watch on the exercise

Unmanned systems and vehicles combine for Royal Navy operation HELEN KNIGHT REPORTS

Unmaned vehicles will be put through their paces this month, as part of a major exercise by the Royal Navy. The Unmanned Warrior exercise, being held off the coast of Scotland, will involve over 50 vehicles, sensors and systems, and is designed to demonstrate the potential of autonomous maritime systems in defence operations.

As part of the exercise, Thales will be deploying its Watchkeeper Unmanned Aircraft System and Halcyon Unmanned Surface Vehicle.

Watchkeeper will be flying offshore for the first time, operating alongside a Type 23 warship and merchant vessel.

The aircraft, fitted with a video camera and I-Master radar, will be used to carry out reconnaissance and intelligence operations, according to Nick Miller, unmanned aircraft systems business capture director at Thales.

During the operation, which will

take place over Cardigan Bay in Wales a week before Unmanned Warrior, Watchkeeper will be integrated into a series of exercises. These will include detecting and tracking small, high-speed potential threats up to 150km offshore, as well as supporting landing forces and providing naval gunfire support.

"The intelligence data we pick up using the airborne payloads on board Watchkeeper will be beamed down to a combat management system on the naval vessel," said Miller.

The data will then be analysed by trained operators on board the vessel.

The system will also be connected to MAPLE (Maritime Autonomous Platform Exploitation), a transportable combat management system. The MAPLE programme, which is being developed by Thales, BAE Systems, Qinetiq and SeeByte, will allow multiple unmanned vehicles to be commanded and controlled from a single station.

Meanwhile Thales' Halcyon Unmanned Surface Vehicle, equipped

with Towed Synthetic Aperture Sonar, will be taking part in the main exercise, off the coast of Scotland.

Halcyon will take part in a number of mine-hunting operations, designed to demonstrate the benefits of using autonomous systems in hostile environments, not least in keeping human crews out of harm's way, said Jason Dey, product line manager for mine warfare at Thales UK.

"We want to be able to show the maturity of technology for remote mine-hunting missions," he said. "At the moment it [Royal Navy] will send an expensive mine-hunter with 40 or 50 people into the minefield, and this is a way of keeping people out of that minefield."

During the exercise, Halcyon will tow the sonar through the water, to survey a section of the seabed. To do this, the unmanned vehicle will travel up and down 'tracks', allowing the sonar to comprehensively survey the area.

"We're focusing on the quality of the images, and how accurately we can determine what kind of things we are getting echoes from on the seabed," said Dey.

This will create a challenge for the combined autonomous system, as the unmanned vehicle will have to ensure each time it takes a turn up and down the tracks it does not lose tension in the cable towing the sonar, which could cause it to ditch, said Dey. It will also need to ensure it then approaches the next track in a straight line. ☐

Watchkeeper will operate alongside a Type 23 warship



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RAIL

How to deal with leaves on the line

Company uses microwave energy to dry out a section of the track

JASON FORD REPORTS

Keats described autumn as the 'season of mists and mellow fruitfulness' but for Network Rail, train

operators and travellers alike it is often the cause of disruption.

The source of this interruption to services can be found in the leaves falling onto railway lines and being turned into a Teflon-like mulch by trains passing over them.

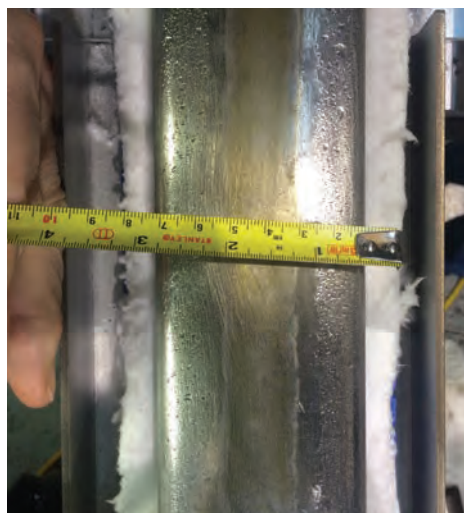
Consequently, this slippery coating requires train drivers to brake earlier when approaching stations and signals, then accelerate cautiously to avoid wheel spin.

The situation is so pronounced that annual timetable adjustments are made, a situation that London-based Imagination Factory hopes to alleviate with bursts of microwave energy to dry out a section of the track.

In 2014, the company was one of seven organisations that were awarded funding by the Rail Safety and Standards Board (RSSB) to take forward its solution as part

of the 'Predictable and Optimised Braking Challenge'.

The company's solution would see microwave energy directed at railway tracks during braking.



The patch between the rail and wheel interface

Julian Swan, engineering lead and co-founder of Imagination Factory, said that the idea is to dry the contact patch between the rail and wheel interface, which is approximately 12mm wide.

"We are not intending to dry the full track width," he said. "Our design vision is to have a modular approach to enable us to treat the tracks individually and progressively down the length of the train."

For the microwave element, Swan explained that the initial proof-of-concept rig operated at 6kW using an 896MHz source but that, in the next phase of development, the company will investigate 2.3GHz, as this has the potential to improve energy density and component compactness.

Imagination Factory proposes separating the power electronics from the microwave generation by the use of COAX cabling.

"This will enable us to locate some of the larger more sensitive pieces of equipment on the sprung chassis of the carriage and the more robust solid-state elements of the microwave antenna can be located near the wheel," said Swan. "This flexible modular-build principle should enable the final design to be retrofitted, as well as incorporated in new build."

So far, scale tests have been completed at 1mph but Swan added that the company's mathematical model suggests a linear relationship enabling full effect at up to 50mph.

"We hope to demonstrate this during the next phase of funded development through the RSSB," he said. "The energy used for the system during braking could also be created by regenerative braking. Currently regen brakes are not able to return the energy to the grid due to the quality of what is created. This system could utilise this energy easily." ©

Newsinbrief

Shipping's a gas

Ineos has received its first shipment of ethane derived from US shale gas. The ethane will be used as a supplementary feed for the Ineos KG ethylene plant in Grangemouth, Scotland, which was recommissioned following its mothballing in 2008. The delivery was the first from a series of Dragon-class ships that will create a so-called 'virtual pipeline' across the Atlantic.

A sporting return

Jaguar Land Rover is investing £100m in its Castle Bromwich plant to support the production of the Jaguar XE, the firm's mid-priced premium sport sedan. This new investment takes the total spent on the site to more than £500m over the last two years, and marks the return of all Jaguar's sports and saloon car manufacturing to the plant.

Rate of acceleration

The CBI's latest *Industrial Trends Survey* has found manufacturers are expecting the rate of production to accelerate. The survey of 481 firms found that those in 11 of the 18 sub-sectors are upgrading their expectations for output over the next quarter. Export order books weakened slightly, with chemical firms experiencing the sharpest drop in overseas demand, contrasting with the motor vehicle and transport sector, which reported the greatest improvement.

Brum enterprise

Birmingham has been named the 'most enterprising place in Britain' by the 2016 Enterprising Britain Awards, small-business minister Margot James announced on 24 September 2016. Birmingham City Council teamed up with six Local Enterprise Partnerships to improve confidence, encourage investment, and attract and retain business talent.

MATERIALS

Flax fibres are getting set to go on the road

Composite combines carbon fibres and flax

CHRIS PICKERING REPORTS

Welsh carmaker Riversimple is part of a consortium that has been awarded £125,000 to develop a bio-carbon composite material using flax fibres.

The company will use its hydrogen

fuel cell-powered vehicle, the Rasa, as a test bed for the new material that is being developed in partnership with NetComposites, Chesterfield and KS Composites in Melton Mowbray.

The material combines traditional carbon fibres with flax and epoxy in a layered structure, where the flax acts as the central layer, overcoming the need for a double-cure process.

"One of the traditional problems with carbon-fibre monocoques is their NVH [noise, vibration, and harshness] properties," explained Hugo Spowers, chief engineer and founder of Riversimple. "You get some very significant effects inside the car if you're not careful. We've minimised that in our existing prototype using

sandwich materials, but that requires a lengthy double-cure process."

Creating this central layer from flax eliminates the additional lay-up and curing steps, reducing the time, cost and environmental impact. Spowers cited the recent CARBIO project, which showed that a 50:50 carbon flax laminate had the same bending stiffness as all-carbon but with a 15 per cent reduction in cost, seven per cent lower weight and 58 per cent greater vibration-damping capabilities.

The Riversimple project will be the first time that the material has been tested on a car. Initially, it's likely to be used on the Rasa's rear bodywork, which is non-structural but NVH-critical due to the size of the panel. ©

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MEDICAL

Some good sense for testing blood

New biosensor could do tests in real time and at lower cost JASON FORD REPORTS

Blood tests for the presence of infection or disease could be carried out in real time and at low cost thanks to a sensor developed at York University.

Tests to detect infection or disease require a sample of blood from a patient, which is analysed in a laboratory to detect markers of disease. The presence of certain proteins can give an indication of a health condition and the best course of treatment, but only one type of protein can be identified per sample.

If multiple tests are required the delivery of results can take longer, which increases the cost of tests.

The York biosensor, developed

According to the university, it combines light and electricity in silicon sensors in a way not done before.

PhD student Jose Juan Colas, who conducted the research at the university's Department of Electronics said the sensor consists of nanometre devices that resonate at a specific optical frequency. Since the devices are optical, they are sensitive to changes in the speed at which light propagates locally.

Juan Colas said: "When the environment around these devices changes, the local speed of light varies and thus the resonant frequency is altered. For instance, the surface of the device can be modified so it is also sensitive to a certain protein. In this way, when this protein sticks to the surface, it leads to a change in the resonance frequency.

"The novelty of our sensor is that, by exploiting its electrical properties, we have been able to modify the surface of each of these devices so that each of them can be sensitive to, for example, a different protein." Juan Colas added that this could be performed in an area of only a few square micrometers, which reduces the amount of blood needed from a patient.

The researchers plan to test the new technology in urine samples for urinary tract infections, which have high resistance to antibiotics. ☐



The biosensor can detect multiple disease biomarkers in one smaller sample

"The surface can be modified so it is sensitive to a certain protein"

Jose Juan Colas,
York University

with support from EPSRC, combines light and electricity to detect multiple disease biomarkers in one smaller sample. It could make blood tests more comfortable and enable results to be processed quicker.

AUTOMOTIVE

An autonomous way to combat motion sickness

Simulator aids mitigation of factors causing illness

CHRIS PICKERING REPORTS

The arrival of the autonomous car is set to pose a lot of technical challenges for engineers, but one that's been largely overlooked until now is car sickness.

Norfolk-based simulator specialist Ansible Motion is now working with a number of manufacturers to investigate how this could be mitigated.

Motion sickness stems from other sensory inputs — usually vision — apparently contradicting the movement felt by the body's vestibular system. It's particularly common while reading or watching video footage, which a University of Michigan study concluded were some of the most likely activities for passengers inside a fully autonomous vehicle.

Previous studies have shown that design factors such as the size and shape of the vehicle's windows, along with its ride frequency, can all influence motion sickness.

Where the simulator comes into its own is the ability to modify these characteristics at the touch of a button and run fully repeatable tests without incurring the cost of developing a physical prototype.

"By swapping these components around virtually, designers can see what combination gives the smoothest ride. This means that when the first physical prototypes are created they are already designed to mitigate motion sickness," said Phil Morse, technical liaison officer for Ansible Motion.

This is by no means a straightforward process, however. Traditionally, simulators have struggled with motion cueing and visual latency — so much so that they can have a tendency to induce motion sickness in people who wouldn't normally experience it. This even has a name: Simulator Adaptation Syndrome.

Ansible Motion claims that by carefully studying the responses of the human vestibular system it has been able to create a simulator that not only overcomes these issues during normal running, but actually allows them to be accurately replicated and studied. ☐

AUTOMOTIVE

Fast move for Bloodhound sponsorship

Three-year agreement sees Chinese firm provide technical and financial support to record attempt

China's Zhejiang Geely Holding Group has been named as The Bloodhound Project's prime sponsor and official automotive partner.

The three-year agreement will see Zhejiang Geely Holding Group (ZGH) provide technical and financial support to the project, which aims to break the world land speed record in 2017 by travelling on Hakskeen Pan, South Africa, at 1,000mph.

ZGH owns Volvo Car Group, plus the London Taxi Company, and is the parent company to Geely Auto, which has four international R&D centres, employs approximately 10,000 engineers worldwide and has also established universities, further education colleges and technology schools across China.

The partnership will see Geely Auto technology being used within Bloodhound Supersonic Car; Geely Group vehicles being used in South Africa throughout record campaigns; plus design and engineering support being provided, where required, to help the project.

Jaguar will continue as technical partner to the project and its V8 engine will remain the auxiliary power unit used to power the oxidiser pump for Bloodhound's rocket. **JF**

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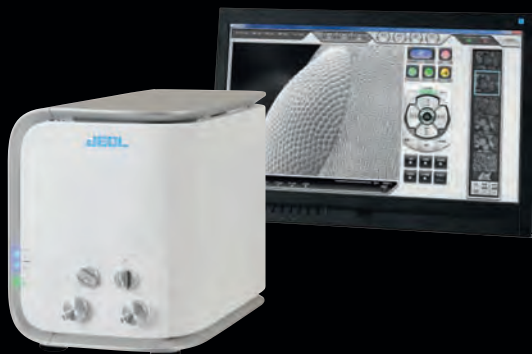
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MANUFACTURING

Keep it clean for food and drink

AI system precisely monitors the levels of dirt on production equipment HELEN KNIGHT REPORTS

A cleaning system being developed in the UK could slash the cost of food and drink production, while reducing water and energy usage, through the use of artificial intelligence (AI).

The AI system, which precisely monitors levels of dirt on equipment to ensure it cleans them effectively, could save the UK industry £100m, its developers claim.

Existing technology used by the food and drink industry to clean processing equipment without disassembling it cannot measure exactly how dirty the vessels are inside, meaning companies can clean for up to five hours each day to prevent contamination.

As a result, cleaning can account for around 30 per cent of the industry's energy and water use.

The AI system, being developed by Derbyshire-based cleaning technology specialist Martec of Whitwell, in collaboration with Nottingham and Loughborough universities, will use ultrasonic sensing and optical fluorescence imaging to measure dirt levels inside equipment.

This could save between 20-50 per cent of the time companies spend cleaning, and increase the amount of time equipment is available for production, according to Ian Sterritt, co-owner and director of Martec.

"One of the biggest problems in food manufacturing is how much time is spent cleaning," he said. "In effect they are cleaning equipment that is already clean."

The system will use optical fluorescence imaging to measure dirt levels inside vessels such as tanks and mixers, said Sterritt. Light of a specific wavelength is shone at the walls of the tank, causing proteins within any food stuffs present to fluoresce, which can be detected by the camera.

Software then studies the

"One of the biggest problems in food is how much time is spent cleaning"

Ian Sterritt,
Martec

generated image pixel by pixel to locate any fouling in real time.

Meanwhile an ultrasonic device is used to image the inside of pipework, said Sterritt. "We have already proven the ability of the two sensing technologies to detect the levels of fouling on the walls," he said.

As part of a year-long feasibility study, the researchers now plan to develop software that can process this sensor data and generate algorithms for an AI-based monitoring system. ©

The system could save 20-50 per cent of the time spent on cleaning



NUCLEAR

Seal of approval

Government gives delayed go-ahead for Hinkley Point C power station

The UK is to get its first nuclear power station since Sizewell B following government approval for the construction of Hinkley Point C in Somerset.

The twin 3.2GW EPR reactor plant will now proceed after government-asserted caveats contained within a new legal framework for future foreign investment in Britain's critical infrastructure, including nuclear plants built after Hinkley.

A decision on the new power station was expected in late July following EDF's commitment to proceed with Hinkley, but this



Hinkley Point C in Somerset

was put back pending a further government review on the project.

Conditions accompanying the approval include a clause preventing the sale of EDF's controlling stake prior to completion of construction, without the prior notification and agreement of ministers. The government will also be able to intervene in the sale of EDF's stake once Hinkley is operational. **JF**

AUTOMOTIVE

Spinning around for electric car range extension

Gas turbine range extender project is moving along

CHRIS PICKERING REPORTS

Delta Motorsport has launched a new gas turbine range extender system that was developed with support from Innovate UK.

Capable of running on petrol, kerosene or diesel, the MiTRE — Micro Turbine Range Extender — spins at up to 120,000rpm to drive a 17kW generator.

"Range extenders are something we've been looking at since about 2010 when we first began developing our own electric vehicle, the E4," said Liam Crabb, Delta Motorsport operations manager.

"Through Innovate UK and our technical partners we've now been able to push the project forward."

The plan is to supply the range extender as a complete system, including

the generator and the power electronics. With all the ancillaries (minus fuel) it is said to weigh approximately 45kg. Delta Motorsport plans to take the design through to production, although that's unlikely to happen in house.

There's also a 35kW variant under development. This larger unit is said to be capable of maintaining the state of charge on a large passenger EV, such as a Tesla, yet the company claims it is approximately 40 per cent smaller and 50 per cent lighter than the equivalent piston engine device.

"A gas turbine is lightweight, small to package and it requires less ancillary systems than a piston engine — there's no external cooling for instance," Crabb said. "The high-speed nature of the project has been challenging at times. Having Schaeffler on board has helped massively with the design of the bearings, while HiETA has provided a sintered heat exchanger, which simplifies what would normally be a very complicated piece of equipment." ©

The Micro Turbine Range Extender



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PROCESS

Belt casting could help steel process

New technology may cut costs and energy consumption in steel production HELEN KNIGHT REPORTS

Steel production, vital to industries such as transportation and construction, is a very expensive and energy-intensive process.

Now an EPSRC-funded project, led by Warwick Manufacturing Group at Warwick University, is investigating a new technology that could dramatically reduce both the cost and the amount of energy consumed by the process.

The Assure 2 project, which also involves McGill University in Canada and Tata Steel, could enable new advanced steels and steel alloys to be produced using the technology, which is known as belt casting.

In conventional steel production the molten material is cast into

“The strip is around 5–10mm thick, so there is very little rolling required”

Claire Davis,
Warwick Manufacturing Group

continuous slabs of around 250mm in thickness. These are cut into lengths, hot rolled and then cold rolled, ultimately producing a strip around 1mm thick. This is hugely energy intensive and steel makers have been exploring ways to improve the efficiency of the process by directly

casting a thin strip of steel, according to project leader Prof Claire Davis of WMG.

“In belt casting, you cast a strip directly onto a moving belt,” said Davis. “This strip is around 5–10mm thick, so there is very little rolling required to produce a product for the automotive industry, for example.”

Energy consumption accounts for around 20–40 per cent of the cost of conventional steel production. A large portion of the energy is consumed in heating and reheating the steel.

Belt casting could reduce this

energy consumption by more than 3GJ per tonne of steel produced, the researchers claim.

The technique could also enable the production of new advanced high-strength strip steel (AHSS) grades, including alloys containing aluminium or manganese. These materials have properties including increased strength and lower density but cannot be produced using conventional processing because it can lead to the creation of cracks, for example, said Davis.

“Belt casting could potentially be used to manufacture these hard-to-produce, high-value AHSS steels in an energy-efficient and cost-efficient way,” she said.

The researchers will investigate the relationship between the belt-casting process and the composition and microstructure of the materials produced in collaboration with McGill University’s Prof Roderick Guthrie, a world-leading authority on belt-casting technology. ©



Belt casting could save 3GJ per tonne of steel produced

BATTERIES

Battery range uses Nissan’s lithium-ion cells

Electric vehicle specialist applies LEAF technology

CHRIS PICKERING REPORTS

Electric vehicle specialist Hyperdrive Innovation has launched a range of battery systems based on lithium-ion cell technology from Nissan.

The Sunderland-based SME is believed to be the first independent company to have commercialised Nissan’s LEAF cells, which are made in the Japanese company’s UK plant.

“We’ve been making lithium-ion batteries for four-and-a-half years. Historically we’ve purchased pouch cells from overseas, but two years ago we approached Nissan with a view to introducing its technology to new niche markets,” said Stephen Irish, managing director of Hyperdrive Innovation.

“The factory is half a mile from our facility, so it has dramatically shortened the supply chain, which has reduced the cost, complexity and carbon footprint of what we do. We’ve worked very closely with Nissan – with not only the manufacturing team in the UK but also the marketing department in Paris and the R&D team in Japan. The Advanced Propulsion Centre and Innovate UK have also been very supportive.”

Hyperdrive combines the Nissan cells with its own battery management system, including bespoke electronics and firmware, inside a specially designed injection-moulded plastic casing. The first battery to be validated will be the 48V, 3.5kWh version.

Each pack has a specific energy of 125Wh/kg and the existing units can be scaled up to 600V by connecting multiple packs.

Planned applications so far include off-highway vehicles, marine propulsion and domestic energy storage. ©



AUTOMOTIVE

SME supply chain competition winners

Focus on accelerating existing low-carbon projects

The Advanced Propulsion Centre and the Niche Vehicle Network have announced the winners of their SME & Supply Chain Development Competition.

The contest is intended to help UK SMEs and their supply chain accelerate the development of existing low-carbon projects. The prize fund was stretched from £1m to £1.3m this year to enable five projects to be

included, with varying grants up to £250,000.

Winners include a consortium led by Ariel Motor Company, which is looking at the combination of aluminium sheet and extruded beam sections with affordable thermoplastic panels to create hybrid material sub-assemblies. Similarly, a consortium led by MCT ReMan is carrying out a supply chain streamlining and upscaling study, including a proof-of-concept for a driveline project and development and publication of a supply chain readiness level tool to support the EV sector.

All winners have around nine months to match the funding and demonstrate their projects. **CP**

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AUTOMOTIVE

Small, light eDrive for plug-in hybrids

GKN Driveline's integrated system will enable carmakers to buy single module HELEN KNIGHT REPORTS

A complete electric-drive system for plug-in hybrid vehicles, developed by GKN Driveline, will enter production with a European carmaker in 2019.

The eDrive system, which is smaller and lighter than existing electric drivelines, will allow carmakers to buy a single module rather than have to source and integrate components.

The module integrates a water-cooled electric motor and inverter with a single-speed eAxle reduction gearbox.

By integrating the various elements of an electric driveline into a single – and smaller – package, the technology can improve the overall system's efficiency and power density, according to Andreas Mair, all-wheel and electric-drive senior director of product technology (mechanical) at GKN Driveline.

"Typically, if I reduce the packaging then I lower the weight and, for electric

and hybrid vehicles in particular, weight is a very important topic," said Mair. "Since the energy is coming from the batteries, the efficiency of the whole drivetrain is something that we have to look at very carefully."

The complete module measures 300mm high and 325mm wide, and weighs 54kg, making it around 20mm narrower and 2.5kg lighter than comparable systems.

This also gives carmakers more options for packaging and assembling the driveline, said Mair.

"If I have three individual components then I have three different housings. So if I can get rid of some of the interfaces [between them] because I have put three or four things together, obviously I'm better off for space," he said.

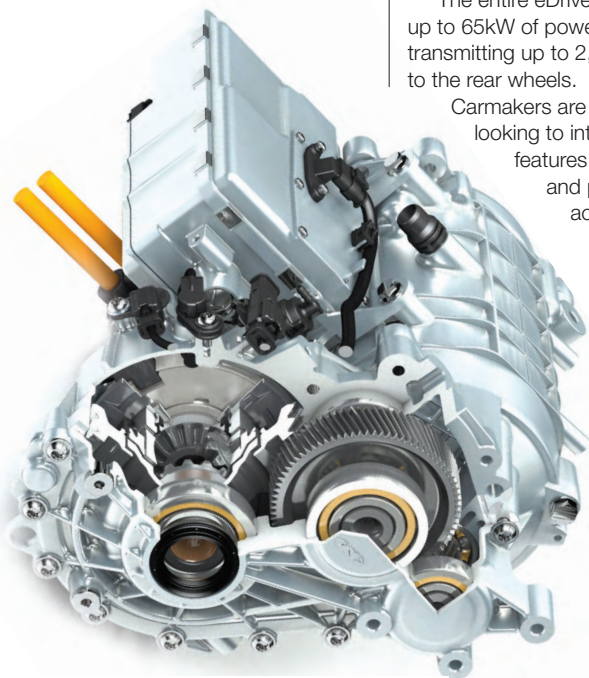
The module is also the first eDrive system to replace external wiring with a busbar – a copper strip designed to carry large electric currents over short distances. This results in a system with higher power density that is easier to install, the company claims.

The entire eDrive system generates up to 65kW of power and is capable of transmitting up to 2,000Nm of torque to the rear wheels.

Carmakers are increasingly looking to integrate more features into all-electric and plug-in hybrid cars, according to Rainer Link, all-wheel and electric-drive vice-president business development director at GKN Driveline.

"With electrification, car makers want to bring more features into the car and still maintain the fun-to-drive element,"

said Link. ■



eDrive delivers near-silent driving

MEDICINE

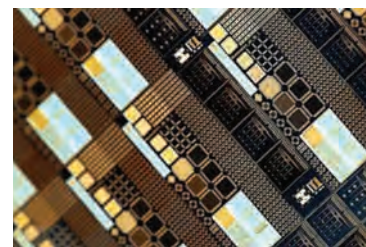
Help for brain conditions

Nanoscale memristors may boost implants through real-time processing of neuronal signals

Nanoscale memristors could provide a significant boost to the development of implants that use electrical signals from the brain to help treat medical conditions.

In a study published in *Nature Communications*, Southampton University researchers showed that memristors could provide real-time processing of neuronal signals – or 'spiking events' – leading to efficient data compression and the potential to develop more precise and affordable neuroprosthetics and bioelectronic medicines.

The team developed a nanoscale memristive integrating sensor (MIS)



Neural activity drives neuroprosthetics

into which it fed a series of voltage time samples, which replicated neuronal electrical activity.

Acting like brain synapses, the metal-oxide MIS was reportedly able to encode and compress up to 200 times the neuronal spiking activity recorded by multi-electrode arrays. Besides addressing the bandwidth constraints, the power needed per recording channel was up to 100 times less than current best practice. **JF**

MILITARY

Hub drive will feature in US AFV programme

Qinetiq system will reduce weight and improve safety

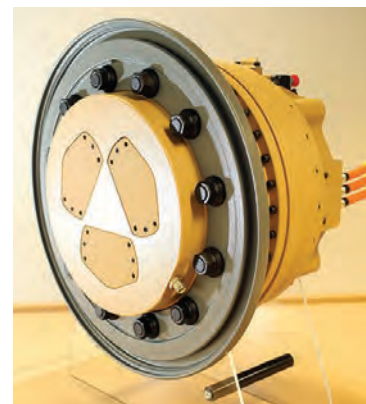
JASON FORD REPORTS

Qinetiq has been awarded \$2.7m to help develop the US military's next generation of armoured fighting vehicles (AFVs).

The Farnborough-based company will apply its electric hub-drive technology to the Ground X-Vehicle Technologies (GXV-T) programme, an initiative launched by the US Defense Advanced Research Projects Agency in August 2014.

The Qinetiq hub drive can replace multiple gearboxes, differentials and driveshafts with compact, high-powered electric motors contained within wheels. The company said this approach reduced the overall weight of the vehicle and introduced new design possibilities that improved safety and increased performance for military and civilian vehicles.

The technology also has the potential to enhance existing military vehicles, such as multiple-wheeled infantry vehicles that could be retrofitted with the hub-drive system to exploit the extra power and agility associated with reduced weight, or



High-powered motor within wheel

use the saving to offset extra armour.

Current armoured vehicles face ordnance that is increasingly effective at penetrating them, but adding armour incurs penalties in terms of vehicle speed, mobility, and increased development and deployment costs. Similarly, conventional drive systems can become lethal projectiles when an explosion occurs beneath the vehicle.

Dr David Moore, director of Research Services at Qinetiq, said: "Moving the drive system to within the wheels removes this threat and disrupts the trend of vehicles becoming heavier and less mobile due to increasing protection and weaponry."

The latest \$2.7m investment, awarded in July 2016, will take the technology from a concept design into the building and testing phase, including production of two fully working units.

Qinetiq is also seeking opportunities to introduce similar hub-drive systems into commercial sectors. ■

supplied by

BECKHOFF

Integrating additive manufacturing with standard CNC machining

Hybrid Manufacturing Technologies has developed a unique CNC-based hybrid tool control solution that enables virtually any CNC machine or robotic platform to deploy both metal-cutting and metal-adding heads in the spindle and conveniently change between them.



Hybrids system uses Beckhoff controls to integrate additive manufacturing with standard CNC machining

Founded as a commercial entity in 2012 by Dr. Jason Jones and Peter Coates, Hybrid Manufacturing Technologies actually began life in 2007 when the active use of a high-speed milling machine was initiated at De Montfort University's Additive Manufacturing (AM) and 3D printing research laboratory. The cross-pollination of additive and subtractive technologies led to a four year, UK-based research project named RECLAIM (REmanufacture of high-value products using a Combined LAser cladding, Inspection and Machining system) with support from the Technology Strategy Board and a number of industrial collaborators.

ADDITIVE MANUFACTURING

Key to the technology is its ability to provide both metal adding and metal removal tools on the same spindle; operations normally undertaken by discrete machines and requiring lengthy additional changeovers and programming steps. This also means that the majority of metal parts made by additive manufacturing can have post-processing operations, such as polishing, milling and surface blasting, performed without

having to locate to another manufacturing cell, resulting in fabrication and surface finishing being achieved in a single setup. The hybrid approach also allows different compositions of materials to be used in the same component, while in-process inspection can assure quality levels otherwise impractical or impossible to evaluate.

The company initially had issues – relating to both the Ethernet communications and the HMI – with its original control solution, which lead to the first contact with Beckhoff Automation in 2014. The result of this collaboration was a control solution that not only addressed the communication and HMI issues, but also facilitated easier connection at customer sites and offered greater capability to expand the solution as the technology and the customers' needs evolve.

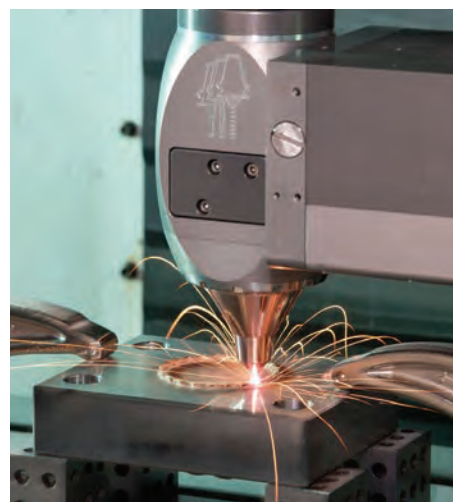
The technology is compatible with most CNC machine configurations and robotic platforms and can be supplied in collaboration with an OEM as an option on a new machine or added as a retrofit to new or used machines already in the field. A machine tool builder adopting Hybrid's system can use it to add additive manufacturing to the capabilities of a

standard machine. Hamuel, for example, first introduced an additive-capable model to a line of their machine tools in 2013 and several other machine tool builders have followed suit.

The current Hybrid system supports a range of AMBIT™ processing heads with different geometries, laser profiles, powder delivery configurations and de-focused energy beams to support tasks including 3D deposition, cladding, marking, cutting, drilling, pre-heating, annealing/stress relieving, surface re-melting and cleaning among others. The default setup accommodates up to 15 processing heads, but it can be expanded indefinitely, subject to space in the tool changer and controller capacity.

Beckhoff's motion control solution comprised a number of elements from its industry-leading portfolio. These included the EK1100 EtherCAT Coupler and other EtherCAT terminals and a Beckhoff CP2218 panel PC running Microsoft Windows 7 and TwinCAT 3 software for programming and control. Hybrid Manufacturing Technologies were particularly impressed by the Beckhoff HMI solution and the ability to deploy EtherCAT in the machine head.

Peter Coates, Co-founder of Hybrid Manufacturing Technologies elaborates on the technology and its capabilities: "We can make bespoke heads for customers, depending on their precise application needs, and these heads can be attached to virtually any machine tool. Looking beyond the machine, Beckhoff's use of EtherCAT means that connection to other cells is straightforward, and being based on a Window platform makes interfacing with Enterprise Systems far simpler from a protocol perspective and can leverage existing communication backbones. We will be looking to deploy Beckhoff systems in our standard product offerings as we expand worldwide, in step with the granting of foundational patents and intellectual property rights around the globe."



The unique head is controlled using Beckhoff's motion control solution

EASY TO USE

Commenting on the move to a new control solution, Peter Coates, explains: "It was a bit of a culture shock, as we were used to working with software and hardware from another supplier, but we were able to do all the programming using the TwinCAT 3 software with minimal training. We found it incredibly easy to use and will exploit further training opportunities to improve our knowledge of the system's capabilities. The beauty of the structured text programming is that we don't have to change the platform, this also allows us to expand it seamlessly by simply adding new PLC code and all of the controls run the same code, which is unbelievably useful. The connectivity will also allow us to license the software in a way that allows users to deploy it on a pay-per-use basis."

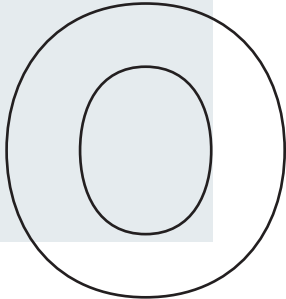
By offering an open architecture running on off-the-shelf software solutions, Beckhoff products can be used as separate components or integrated into a complete and seamless control system. This open approach also facilitates integration into customer sites, especially in relation to the deployment of Ethernet-based control and ERP solutions.

www.beckhoff.co.uk



Fly the flag for additive

Leading figures from UK industry have joined with academia and government to develop a national strategy for additive manufacturing



ur world is evolving rapidly. A growing, longer-living population, a generation of digital toddlers, a changing climate and reducing natural resources are but a few examples of changes we face.

Technology will be at the heart of our response. The speed and manner in which we develop new technologies to a position where industry can reap the full benefit of their potential will be critical to building a successful and balanced UK economy. It is also at the core of what the High Value Manufacturing Catapult is set up to do.

Additive manufacturing (AM), the process whereby materials are joined, usually layer upon layer, to make objects from 3D model digital data, is a prime example of a new manufacturing technology with enormous potential which, when fully realised, will transform product development, supply chains and manufacturing as we know them. While the process isn't exactly new it has only relatively recently found real and growing industrial applications.

AM, also known as 3D printing, has long moved

on from merely producing bright-coloured plastic gadgets and is now used to produce stainless-steel lightweight aerospace components and even transplant organs from hydrogel or biological cells.

We still have much to discover about the full opportunities associated with AM and the inherent threats (e.g. in terms of cyber security and protection of intellectual property). What we can say with confidence is that those businesses and economies that fail to engage with this technology will also fail to reap its benefits.

So it's very significant that leading figures from UK industry have joined forces with academia and government to establish the UK Additive Manufacturing Steering Group.

The group's vision is for the UK to be a leading country in terms of exploiting AM by 2025, not only in terms of producing additive-manufactured parts, but also in terms of developing associated technology and know-how across the whole process chain.

The global market for AM was £3.59bn in 2015 and the UK's market share is around 5 per cent. If we manage to maintain this market share, this could be worth an estimated £5.6bn by 2025. If we manage to increase our market share to an ambitious, yet realistic, 8 per cent, we are looking at approximately 63,000 additional jobs and further growth.

In order to make this vision a reality, the group is working towards the publication of a UK National Additive Manufacturing Strategy in 2017. A strategic approach will be taken with regard to key aspects of AM.

These include design. While AM opens seemingly limitless new design options (allowing for complex, multi-material, integrated

"No other country has a specific strategy for additive manufacturing"

Dick Elsy

design impossible to make using conventional manufacturing methods), there is a lack of easily accessible up-to-date information and support for designers and businesses.

In relation to materials and processes, as the range of materials used in AM continues to grow, we need to capture best practice and lessons learnt from current practitioners in processes and materials in order to improve AM applications and help build and strengthen the UK supply chain for AM.

The demand for STEM students and engineering apprentices in the UK is well documented. In the case of AM specifically, we need to work with schools and providers of higher, vocational and professional education, and learning to generate more suitable candidates to work with AM technologies.

Securing finance for innovation is a challenge in the UK, and AM, which is still relatively new to many investors, is no exception. Sharing success stories of AM investment to industry and providing funding mechanisms may help overcome this issue.

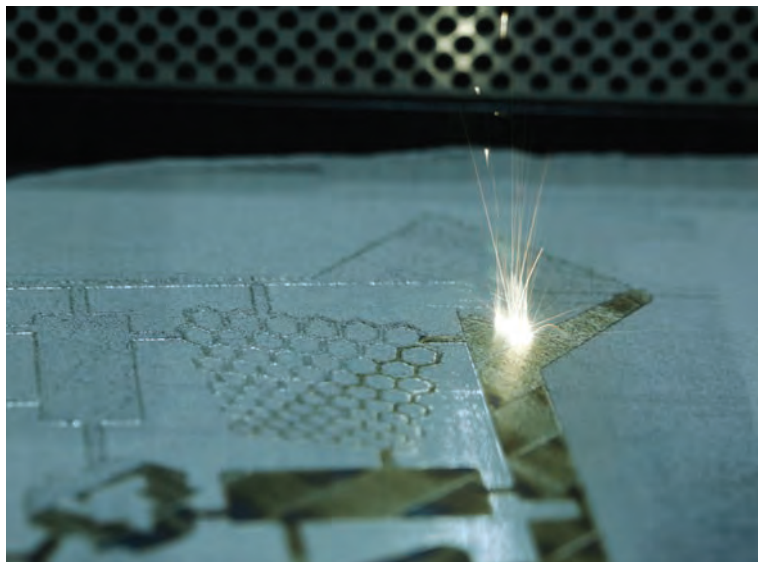
Advances in encryption and security, potential refinements in intellectual property law across the globe and development of specific high-level skills will help us mitigate threats in cyber security and protection of intellectual property.

As the AM industry matures, it needs to strengthen areas such as standards, regulation, certification, inspection, testing and quality control in order to obtain the level of confidence it deserves.

I am convinced that a robust national strategy, underpinned by sector-specific economic plans, and supported by industry, will be invaluable in setting out the path towards maintaining and growing our market share in this disruptive technology.

This is an excellent example of industry, academia and government working together to give the UK a competitive edge, as no other country has an explicit national strategy for additive manufacturing. ®

Dick Elsy is chief executive of the High Value Manufacturing Catapult.
www.amnationalstrategy.uk



AM opens seemingly limitless design options for its industrial users

Image: HVM Catapult



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Mailbox

The hot topic

Cooking on gas

Should the UK be doing more to kick-start its own shale gas industry?



Image: Simon Fraser University

In as short a timescale as 20 years, the UK has gone from being largely self-sufficient in primary energy to being almost totally dependent upon other countries. This also applies to the costs of purchasing power plant for the future. Fracking is our only short-term hope of improving this economically and politically risky situation. The last year or so has fortunately had exceptionally low energy prices so that the economy has not suffered too badly; but, how long will this carry on and what then? Can our

ever-expanding services sector earn the money to purchase the fuel needed, not to mention the replacement generating plant?

Jack Broughton

We can import from the US, which is paid dearly to produce this shale gas. There is no need to ruin the UK's countryside nor the public health of our people when US-produced shale gas is inexpensive. Our own production will not be worth the price, neither economically nor environmentally.

Alex Coates

Fracking should be supported, but there should be some taxes levied to support the growth of alternative greener energy sources and to make sure that fracking safety is properly researched and policed. This would be a good model to give us the time and money to develop alternative energy sources, which are not going to be ready to meet our needs in the short term.

John

The US is large enough for the impact of fracking to have a relatively small effect on the population. We are lucky enough to live on a windy island with

high tidal rises, with many rivers and estuaries, I feel the money would be better invested in eco-friendly renewables.

Alan

Long term, we need to support high-energy manufacturing industries such as the production of steel at Port Talbot. Lower-priced energy is vital to the UK. Renewable energy is great news but there is just not enough power. On a cold night in December/January with no wind and high pressure we will not produce enough energy. Fracking and several gas power stations, which can be switched on and off quickly, provide the answer.

Richard Jordan

Huge quantities of North Sea oil and gas caused stagnation in the development of alternative energy, and better efficiencies. We still have poorly insulated Victorian housing stock that will continue to leak energy until it becomes cost effective to retrofit insulation. Our shale gas reserves are large, but they are not going anywhere. We might need them in 50 years, and so we should not be burning them now. As feedstock it has a value but with cheap ethane from the US it seems silly to extract it now. Wait until the price is higher, and the technology is better understood.

David Allen

In 50 years, the UK needs to be getting all its electric power from clean sources such as nuclear. The gas won't be needed then, unless we want to export it to Germany. Best use it now and cut down imports from countries without proper environmental controls.

Alex T

There remains too much uncertainty about what happens underground, and what happens if it goes wrong. Will the company concerned sort it out or will it go bust leaving us to live with and pay for the consequences? We know we can get gas (and oil) out of the ground in this manner but this is largely from an uncontained location.

Nick Cole

In your opinion

Rotary races

Last month saw the launch of a rotary engine-powered British sports car

I am pleased to note the recent resurgence of interest in this motor for road and aero applications. It has survived innumerable predictions of its demise, probably due to its significant size and weight advantages over conventional motors.

Tony Marshall

It's good to see this type of engine being pursued once again. I had some experience with the former Wankel and some of the headaches it caused but I also was privileged to have seen the rotary applied to

cars other than Mazdas. I was once offered a go with a MKIII Spitfire modified with a standard Wankel and another one with a more race-adapted Australian rotary engine being used in race cars at the time. The performance of these two engines outpaced everything around them.

Rex Willoughby

A friend of mine fitted the Mazda RX7 bi-turbo engine to his Caterham in 2000–02. It was a long-term project for him but once fitted and tuned it was a great track-day car, although he would spin its wheels at every opportunity and the fuel economy was mid-teens, so it was not a good daily drive. Nothing new here, but it should be a great race car.

Chris

Sounds promising, but could it be modified to run economically on hydrogen, a vital characteristic of any future zero-carbon motor? A small quiet rotary, powering small and medium cars at 100mpg equivalent, would be really something – forget

'sport', we need environmental common sense.

Mike Koefman

On a wing and a prayer?

Readers debate technologies aimed at reducing the environmental impact of civil aviation

In relation to this part of the article: "This idea that engines could be built into the wings of an aircraft rather than hanging below them in order to create a more aerodynamic shape (and so require less fuel) is on the long-term horizon of major companies such as Airbus and Rolls-Royce." Anyone remember the Comet 4B? It always looked a better aircraft as well.

Steve

It wasn't only the Comet with the engine built into the wing; do readers remember the Avro Vulcan that only stopped flying last year?

Rolf Clayton



The secret engineer

Robot Wars can only help inspire the next generation of wannabe engineers



I feel certain that I cannot be the only reader of *The Engineer* who watches *Robot Wars*. I would wager that someone reading this article has actually entered it.

The latest series has just finished on BBC2. In case you are oblivious, this is a competition where robots built within certain parameters set upon each other within an arena. The last robot standing (well, moving) wins.

Although one could possibly dismiss it as frippery, there is an admirable amount of information disseminated about the robots and technical aspects of their construction. Members of the expert judging panel are also regularly wheeled out in front of the camera to discuss a particular field of robotics or the future of the science as they see it. It may not be subtle but through all of these mechanisms it is still education about engineering by stealth.

As you would expect, a number of the entrants have been designed and built by engineers. Not only experienced old boys with a fully fitted-out workshop in their shed but also young guns out to prove themselves in the public

arena. Alongside them though, there are constructors without any engineering background at all.

For me, there were two of these latter teams that were particularly notable this year: one a builder who created a robot on his own and the other a gaggle of holiday-camp entertainers. Both teams produced robots that were effective engineered solutions to the design brief, as well as sporting a very high level of finish.

Assuming that by the time this article is published anyone with the least interest will know the result of the final, I feel safe in giving my views on it.

Professional loyalty had me hoping that the Carbide team, led by an engineer, would win. Well, that and the dramatic destruction invariably wrought by its heavy, spinning blade. A little part of me however was rooting for Apollo, the robot built by the entertainers. It never excited me as a fighting robot but the team had taken on the house robots (professionally built, bigger devices controlled by the production team) during the heats and this was so far removed from their area of expertise that you could not help but admire what they had achieved.

Incredibly Apollo won, and deservedly lifted the trophy. Personally I think ripples from this may spread wide. It is my hope that this victory not only inspires more non-engineers to start building in their garden sheds but also encourages those who might be scared by the academic side of our profession to give it a go.

Engineering has many levels and a requirement for a broad spread of abilities. Many a career in engineering could find its start in a shed by helping to build a dodgy-looking robot.

I had a boss in the US in the late 1960s who believed that had we copied the lazy birds first (those that let the wind do the work, keeping their wings still) we would be 25 years ahead in aviation theory and practice.

Mike Blamey

As a general observation it has to be said that for a cleaner and lighter wing the often-used practice of 'engine in or near wing root' has many examples as mentioned, Vulcan, Comet not to mention AW52, Victor, Valiant, Short Sealand, TSR2, Nimrod (a grown-up Comet I know), Javelin, Sea Vixen and so on. But the principle is well proven it seems and so much data must exist to drive the future of continued design.

Stephen Rose

In the last decade, *The Engineer* has twice reported research into a powered undercarriage for airliners. Using electric motors powered from the aircraft's auxiliary power unit, these would provide all taxiing

drives, so that the main engines would not need to be started until nearing the end of the taxiway, and could be shut down very soon after landing. Potential savings in fuel and emissions would be significant, partly because the main engines are very inefficient when used for taxiing.

Tim Forcer

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WE CREATE MOTION



Good news for diversity

Increasing female participation in STEM subjects and careers can help to reduce the UK gender pay gap

“Girls respond well to the opportunity to get hands on and hear directly from STEM professionals”

Paul Jackson

R

ecent research from Deloitte has offered some good news for diversity in engineering.

It showed that increasing female participation in STEM subjects and STEM careers will help to reduce the UK gender pay gap. Although the research predicts that at the current rate the gap won't close until 2069, it's far smaller within STEM starting salaries than elsewhere in the economy, and there's no difference in the median starting salary between men and women in engineering. That's important for productivity because engineering is an essential

foundation for a high-skill, well-paid, productive economy. This bears repeating, particularly during the party conference season.

Deloitte's Emma Codd said: "More must be done to encourage girls from an early age to consider a full range of STEM career options and understand the impact that their choice of studies can have on their career options."

That's a familiar refrain. All young people need to know what the opportunities are, understand what subjects give them the best opportunities and to draw inspiration from role models already in the field.

What we see from Tomorrow's Engineers and The Big Bang programme is that girls respond well to the opportunity to get hands on and hear directly from STEM professionals. This improves their knowledge and perception of the work those professionals do day to day and, as a result, they are more likely to see themselves as part of that workforce.

When choosing subjects that will give them the chance to work in STEM, girls only make up one-fifth of A-level physics students (even though the split of top grades at GCSE is reasonably equal when broken down by gender). Fast forward to those applying for engineering degrees and less than 13 per cent are female. However you look at it, it's clear that this needs to change.

Education and policymakers have a role in bringing about that change, but employers play a key part in creating that essential moment of inspiration and converting it to aspiration. Many of the companies gearing up for Tomorrow's Engineers Week next month are keen to feature the contribution of women they employ to inspire more girls into the industry.

At a STEM conference organised by the Employers Network for Equality & Inclusion (ENEI) late last month, there was a real and collective desire to work to address the skills shortage.

STEM skills are a critical part of the industries and companies represented, from banking to energy and major infrastructure. There was a tremendous mix of people: host Santander's UK chief information officer, an apprentice and a graduate from Cobham, and representatives from the British Antarctic Survey, for example.

This was a group of employers ready to support a diverse set of recruits with the skills and creativity to drive their businesses. I'm telling all the politicians I meet at the party conferences what an opportunity this presents. We need to make the case very clearly or they might just dream up an industrial strategy based on low exchange rates and shopping.

I look forward to working with ENEI to share what we have learned through the Tomorrow's Engineers programme and to support employers who recognise the need to act to attract talent of all kinds. @

Paul Jackson, chief executive, EngineeringUK



Less than 13% of applicants to engineering degrees are female



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Down on the floating farm

Floating turbines that can operate far out at sea could help the renewable sector make better use of offshore wind. Helen Knight reports

From the surface, the spinning blades of the wind turbine sitting off the coast of Norway look much like those of any other offshore device.

But it is underneath the waves where the difference becomes clear.

That is because unlike conventional offshore wind turbines, the Hywind device is not fixed to the seabed by foundations, but is instead attached to a cylindrical structure that floats in the water. Tethers anchored to the ocean floor prevent it from drifting out to sea.

Now the company behind the floating turbine, Statoil, is planning to build five 6MW devices off the coast of Scotland.

The 30MW pilot wind farm, which is due to be completed in 2017 near Buchan Deep, around 25km off the coast of Peterhead in Aberdeenshire, will be the first array of its kind. It is expected to generate around 135GWh of energy per year, or enough electricity to power 20,000 homes.

Unlike fixed offshore wind turbines, floating devices can be placed in deeper waters of up to 150m. This allows them to tap into the vast energy resources available further offshore, where wind speeds tend to be higher and steadier. Turbulence is also lower further offshore, which should ensure the turbines have a longer operating life.

In Europe, over half of the North Sea is considered suitable for floating wind farms, with water depths of between 50m and 220m. The European Wind Energy Association estimates that energy from turbines at depths of over 50m in the North Sea could meet the EU's electricity needs four times over. As a result, the technology is generating increasing interest around the world, with projects already under construction or in the pipeline around the coast of Europe, Japan and the US.

In the UK, these projects are around the coast of Scotland, including the Buchan Deep site and a further two pilot farms planned near Kincardine and Dounreay.

The UK is already an acknowledged world leader in offshore wind power, with over 5GW of installed capacity. The Energy Technologies Institute, a public-private partnership between the UK government and energy companies, estimates that this could increase to between 20–55GW by 2050.

But at these levels, the number of attractive sites for fixed-bed wind turbines, less than 30km from the shore and where water depths are no greater than 40m, are likely to be few and far between. Building fixed offshore turbines in sites that are further from the shore, or in deeper waters, adds considerably to the cost and complexity of any project.

Conditions on the ocean floor can also add to the difficulties, and cost, of building fixed offshore turbines, according to Rhodri James, manager for policy and

innovation at the Carbon Trust, which published a detailed report on floating wind in 2015.

"A number of fixed projects have found themselves facing quite complex seabeds, particularly where the soil is harder, so there are opportunities to locate floating wind where you wouldn't be able to locate a fixed wind farm," said James.

What's more, installing floating wind turbines offshore is cheaper and simpler than fixed devices. That is because expensive heavy-lift vessels are needed to assemble and install fixed turbines on the seabed.

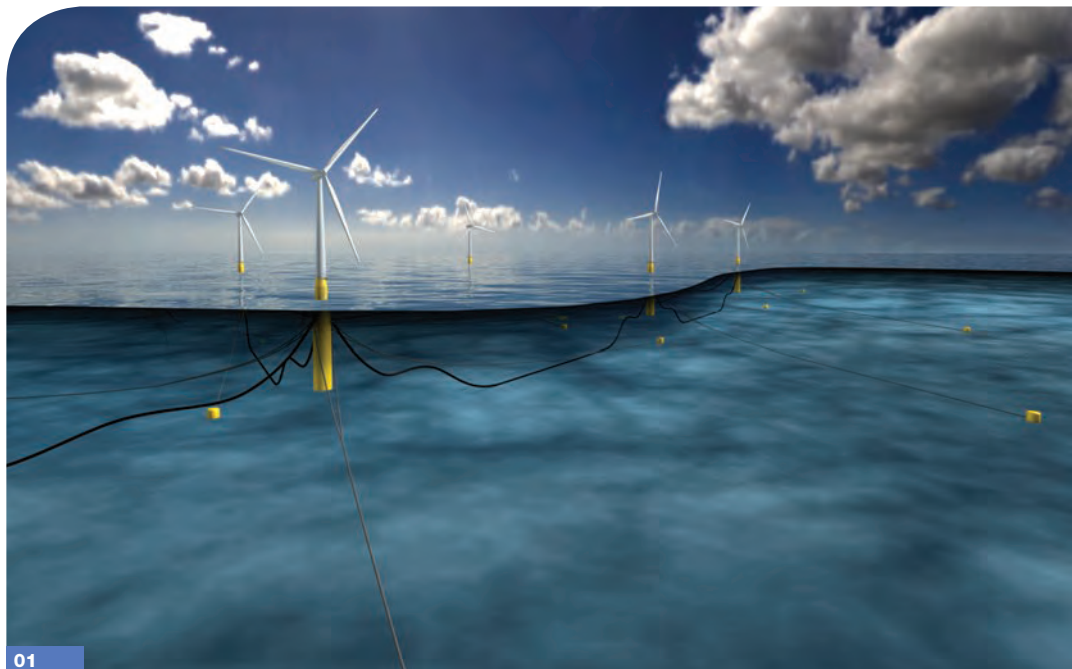
In contrast, most floating wind devices can be fully assembled at port-side, and then simply towed to their offshore location using lower-cost and readily available tug vessels, said James.

This is likely to make a considerable difference as the industry moves from 4–6MW turbines to 8–10MW and above, he said. "The ability to assemble the devices at port-side and tow them to site should work in the favour of floating wind over the next 10–15 years or so, as turbine sizes increase."

As a result, floating offshore wind farms should start to become increasingly attractive, said James.

01 Artist's impression of the Buchan Deep floating wind farm

02 The 2MW WindFloat turbine off the coast of Portugal



"A number of fixed projects have found themselves facing quite complex seabeds"

Rhodri James, Carbon Trust

This is particularly the case in Scotland, where there are high offshore wind speeds and a large number of sites at which waters become deep relatively close to the shore.

At Buchan Deep, Statoil plans to locate its Hywind devices in water depths of around 95–120m. Each device will consist of a turbine placed on top of a ballasted steel cylinder, known as a spar-buoy.

The structures will be anchored to the seabed using three mooring lines, while a pitch motion controller will prevent them moving around too

much in the wind and waves.

According to Statoil, the Hywind structures can be used with any type of wind turbine, providing the combined weight of the nacelle and rotor do not fall outside the levels required to maintain stability.

A pilot Hywind device, installed off the coast of Norway and equipped with a 2.3MW Siemens turbine, has operated successfully since 2009, making it the world's first full-scale floating wind turbine, according to Elin Isaksen, spokesperson for Statoil. In that time, it has generated around 35GW of electricity.

"The experience from the Hywind Demo has been used to further optimise the floater motion controller, so that the movement can be even better controlled," she said. "This will become increasingly important as the turbine size increases."

The company hopes the plant will open up new possibilities for floating

wind around the globe, including the US and Japan. "We believe industrialisation of floating wind is a key opportunity for companies such as ours with skill-sets from the oil and gas business," she said.

The Hywind plant will also pilot the use of batteries to store excess energy produced by the floating turbines for use at periods of high demand. A 1MWh lithium battery-based storage system, known as Batwind, will be installed at the site in late 2018, under an agreement between Statoil, the Scottish government, the Offshore Renewable Energy Catapult and Scottish Enterprise.

But while the Hywind plant will mark the first time multiple turbines have been installed together as an array, it is by no means the only project designed to take advantage of the winds in deeper waters.

In Japan, a project known as Fukushima Forward has been installing floating turbines at its site 20km off the coast of north-east mainland Japan since 2013.

The Fukushima nuclear disaster in 2011 stimulated Japanese interest in alternative, renewable technologies, and in particular focused efforts into offshore wind power. Unlike the UK though, Japan is surrounded by deep water, making it unsuitable for fixed-bed offshore wind, but a prime candidate for floating turbines.

In 2013, the Fukushima Forward project installed one 2MW Hitachi turbine and a floating substation at the site, which was followed in 2015 by a 7MW device, built by Mitsubishi Heavy Industries. In July this year the team installed a final 5MW Hitachi turbine, dubbed the Fukushima Hamakaze, making it the largest floating wind farm in the world, at 14MW.

Unlike the Hywind devices, the 2MW and 7MW Fukushima turbines are both installed on semi-submersibles, or buoyancy-stabilised platforms that float, semi-submerged, on the surface of the water. Mooring lines anchor the platforms to the seabed.

The four-column semi-submersible platform used to support the 2MW Fukushima Mirai turbine, which was built by Mitsui, has already survived an earthquake, measuring 7.1 on the Richter scale, and minor tsunami, as well as two typhoons.

The 7MW Fukushima Shimpuu turbine, meanwhile, is installed on a v-shaped semi-submersible, with three columns, including one supporting the turbine.

In contrast, the floating substation and Hamakaze turbine are installed on an advanced spar design, built by Japan Marine United. This consists of a shorter cylinder than conventional spar-buoy structures like Hywind, for use in shallower waters. Fins fitted around the bottom of the spar help minimise sway in the water. >>





03

>> But despite the apparent success of Fukushima Forward so far, the project has been expensive, according to James. And while Japan has built up a great deal of knowledge about floating wind in the process of this work, the country lacks the advantage of the offshore know-how and infrastructure built up in Europe through the fixed wind and oil and gas industries, he said.

"However, it will be interesting to see what they do beyond this stage of the project," said James. "There has been talk of building the same site out, originally to 1GW, although it may well be closer to 100MW, in time for the Tokyo Games in 2020."

Meanwhile, a 2MW prototype floating turbine, known as WindFloat, is also generating energy off the coast of Aguçadoura in Portugal. The device, which was developed by US-based Principle Power, has already provided more than 16GWh of electricity to the local grid, since its installation in 2011.

The company is now planning to build a three 8.3MW turbine array at the site. Like the prototype, the WindFloat turbines will sit on a semi-submersible hub consisting of three columns.

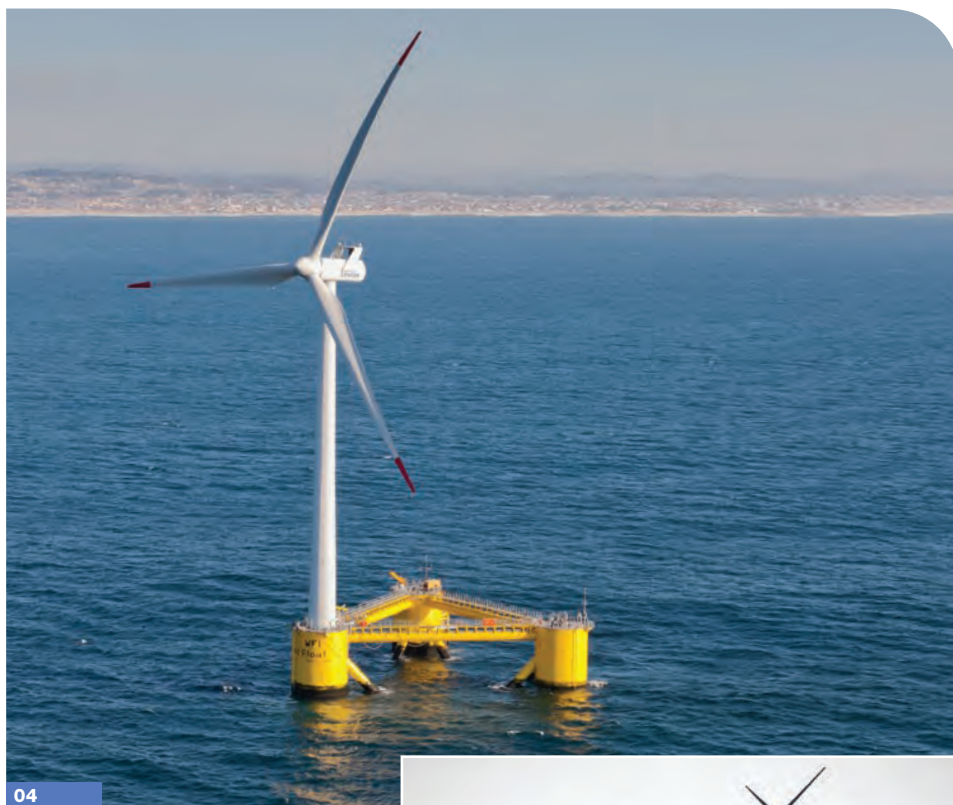
Principle Power also has plans for a further plant off the coast of Scotland, as well as arrays in Hawaii and Oregon in the US.

This summer, French offshore wind power firm Eolfi won a bid to build a floating wind farm consisting of four 6MW General Electric turbines off Groix Island, on the coast of Brittany. The turbines will sit atop four-columned semi-submersible floaters built by French naval manufacturer DCNS, in collaboration with construction company Vinci.

03 Prototype Hywind turbine

04 WindFloat has already provided more than 16GWh of electricity

05 Buchan Deep off the Peterhead coast will be the first array of its kind



04

The wind farm, which will be anchored around 14km from the coast and connected to the shore by underwater cables, has a 20-year power purchase agreement in place.

Each 8m-wide star-shaped floater is built from concrete and steel, and ballasted with 7,000 tonnes of seawater, according to Marc Lanne, maritime senior project manager at Eolfi.

"We hope to have the devices installed at sea in 2020, which is quite an aggressive target," he said.

France has woken up relatively late to the opportunities, said Lanne. As such, the country missed the boat in benefitting from first-mover advantage in fixed-bed offshore wind, but now recognises the opportunities offered by floating wind, he said.

"With floating wind, it's more flexible, it's further from the coast, which means it is less obtrusive, and manufacturing is easier because everything can be constructed in the harbour," said Lanne.

Once the pilot wind farm is in operation, Eolfi hopes to be able to move quickly to build a commercial plant in a few years. And although the company is currently reliant on French government grants, it hopes to be able to compete with market prices for offshore wind in 10–15 years.

Likewise, Statoil estimates that it can ultimately reach a levelised cost of electricity (LCOE) from its floating wind farms of £85–95/MWh.



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"With floating wind, it's more flexible, it's further from the coast and less obtrusive"

Marc Lanne, Eolfi

So far, the data from technology developers suggests that this figure should be achievable, and should ultimately allow it to compete on cost with fixed wind, according to the Carbon Trust's James.

"Floating wind is going to be more expensive than fixed wind for at least the next five years, and probably the next 10 years, but the costs can certainly come down," he said. "Certainly by 2030, there are studies to show it should start to reach parity with fixed wind."

But floating wind will only succeed if it is given the right support, he argues. In the past the technology has suffered somewhat by being placed in the same category as fixed offshore wind. Instead, it needs to be treated as a separate technology in its own right, with its own support mechanisms put in place.

But if the technology is given the support it needs, the Hywind plant could be the first of many wind farms floating off our shores. ☐

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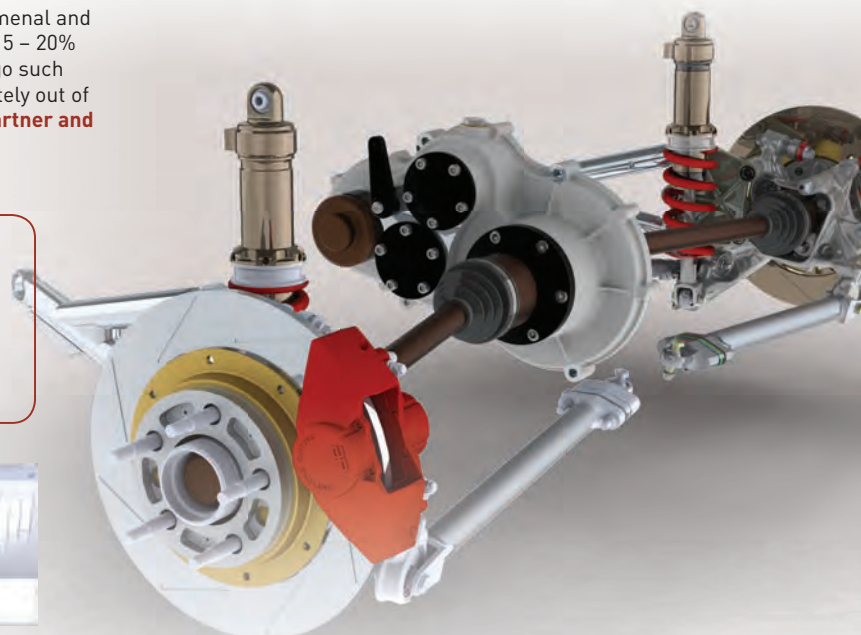


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Exploring the vinyl frontier

As the original album format makes a comeback, Jon Excell meets one of the UK's turntable pioneers

For most manufacturers, unprecedented spiralling demand for products is the stuff of dreams. But Roy Gandy – owner and founder of celebrated UK turntable manufacturer Rega – isn't most manufacturers.

In recent years vinyl has been making a comeback. Last year 2.1 million LPs were sold in the UK, marking a 21-year high for the format, while sales in the US now contribute more to the music industry than digital streaming.

Against this backdrop, Rega has enjoyed unprecedented growth: tripling its turnover in the past five years, expanding its Southend production facility, and cementing its status as

the UK's largest manufacturer of high-end turntables.

But for Gandy – a revered figure among audiophiles – all this commercial success has become something of a distraction from the business of making better and better turntables for people who appreciate high-quality audio. "We wanted it to be 10 people all enjoying themselves," he told *The Engineer*. "It just grew because of demand and you have to meet demand – although we tried not to for a few years."

On the surface it's a refreshingly unconventional approach but, in reality, and somewhat ironically given his professed lack of interest in chasing the mass market, Gandy's relentless engineer's focus on improving his core product is perhaps one of the main reasons for the company's success.

A mechanical engineer by training, Gandy began his career working

with Ford. But after hard times drove him to build his own hi-fi system from components scavenged from friends, he decided that making turntables was much more fun and, in 1973, launched Rega.

Today, the firm produces around 3,500 turntables per month, employs 120 people, and exports to more than 40 different countries. But the obsessive focus on technical innovation and continuous improvement that's attracted so many admirers over the years is still very much at the heart of what Rega does.

For Gandy and his team, the record player is a precision measuring device; a finely honed system optimised to track and interpret the microscopic features of a groove on a record as accurately as possible.

As with many engineered systems, the basics of a record player are relatively simple. Indeed, many of the fundamental principles are unchanged since Edison's 1877 invention of the phonograph. But, over the last three decades, Gandy and his team have refined almost every aspect of this elegant device.

One of the key areas of development has been in the tone arm, the component that must allow the cartridge (the assembly on which the stylus is mounted) free movement across the record. The challenge here is to minimise any vibrations that could affect the measurement. And Rega's introduction, in the 1980s, of a single-piece cast-aluminium tone arm was viewed as something of a game-changer in this department.

In recent years, the firm has continued to refine tone-arm performance by almost completely eliminating play in the bearings that allow the arms to move across the record. Most recently, in an effort to reduce the need for bearing lubrication, the firm worked with plastic bearing specialist Igus on the development of a bespoke plastic tone-arm bearing. These so-called xiros bearings are currently used in its two highest-selling turntables.

Another area of improvement is the cartridge itself. Thanks to a high-powered neodymium magnet and a meticulously hand-wound coil, Rega's

latest moving coil cartridge, the Apheta 2, is smaller and lighter than its predecessor, enabling it to track the vinyl groove even more accurately.

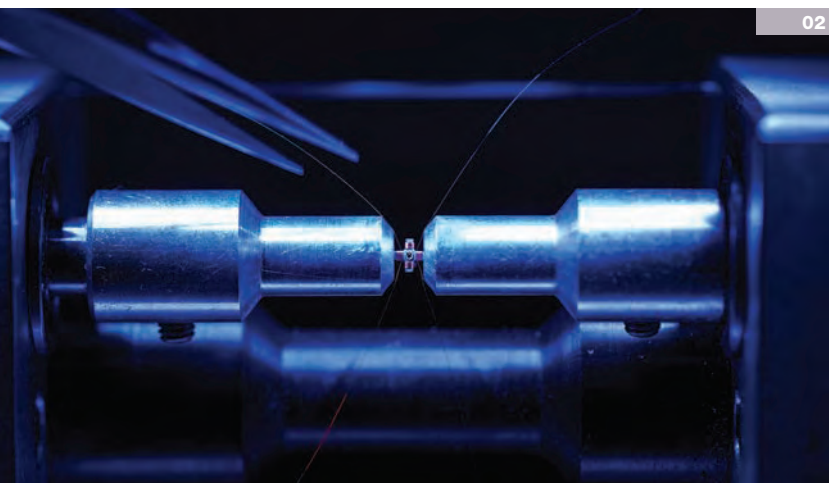
Gandy is keen to stress that the process of refinement often defies convention. A good example is the design of the plinth, or base. While many competitor systems feature heavy plinths, Rega's are made from a lightweight plastic foam encased by a phenolic skin. "Most people want granite or something huge, massive and solid," explained Gandy, "but the heavier it is the more likely it is to transfer noise into the record. The lighter it is the less will get transferred – we've used that concept all our lives. Nobody else has."

However, mass is important in the platter, which must have enough mass to ensure a constant speed but also not so much that it stresses the central bearing. Here, again, Rega's engineers have devised a clever solution: >>



01

01 Rega's top-end turntable, the RP10, without its platter



>> a precision-engineered platter – available in either glass or ceramic material – which has more mass around its edges, thereby limiting the stress on the central bearing but optimising the desired flywheel effect that helps smooth out any quirks of the motor.

Most of Rega's suppliers are based in the UK and Gandy clearly takes great delight in uncovering unlikely pockets of expertise. For instance, the glass platters used on some of the firm's higher-end models are produced by a small family firm in Norfolk that began life making kitchen worktops.

Gandy said he's found it easier to find these kind of expert suppliers in recent years, and believes there's something of an engineering renaissance underway in the UK. "In the last 10 years we've seen this amazing increase of interest in England in engineering excellence. We used to have tortured souls that we used to force to produce things and their only reason for doing it was to get away from



02 Hand-winding the cartridge coil

03 Eliminating play in the tone arm is key

04 Roy Gandy, owner and founder of Rega

"You've got a problem of almost every digital recording being put onto vinyl because it's fashionable. In terms of sound quality, this is a waste of time"

Roy Gandy, Rega

the rest of the world. They used to be really difficult to deal with, but now we've got wonderful companies who are always pushing the edge."

Perhaps surprisingly, far from wanting to fiercely guard all of this hard-won intellectual property Gandy's keen to spread the knowledge, and is even in the process of writing a book about turntable design. "We're really happy if someone tries to copy us," he said. "Part of the reason for writing the book is the hope that we might get some sort of competition, it's healthy. With turntables I've never had anyone to talk to. There are other turntable designers, but if I start trying to talk to them as an engineer they change the subject. I feel lonely!"

The growth of the vinyl industry has undoubtedly been good for business. But Gandy is nevertheless hopeful that it will prove short-lived: partly because meeting demand is a challenge but also because he believes its current popularity has perhaps more to do with fashion than musical quality.

"For us, the reason for vinyl has always been its optimal sound quality – it has the potential, when care has been taken by the recording engineer, the artist and the pressing company, to produce a level of sound quality that exceeds anything that's ever happened in the digital domain. However, there are millions of vinyl albums but only thousands of them sound nice. You've got a problem of almost every digital recording that's been done being put onto vinyl because it's fashionable and, in terms of sound quality, this is a waste of time."

Instead, when looking to the future, he's far more excited about the opportunities presented by the emerging technologies and materials – he singles out graphene as an example – that could help him continue in his lifelong pursuit of the perfect turntable.

"All our requirements are impossible," he said, "we need zero vibration from a motor, a plinth needs to have zero mass but infinite stiffness, a bearing needs to have no friction and no vertical movement but be able to run freely – they're all impossible. But the closer you get to those requirements the more likely you are to achieve your requirements for a turntable." ©



04

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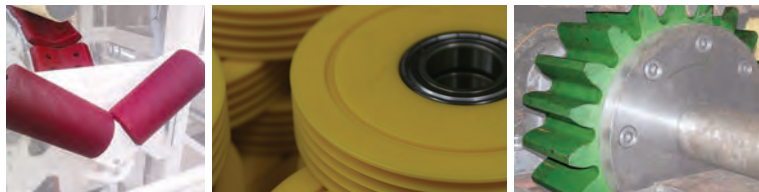
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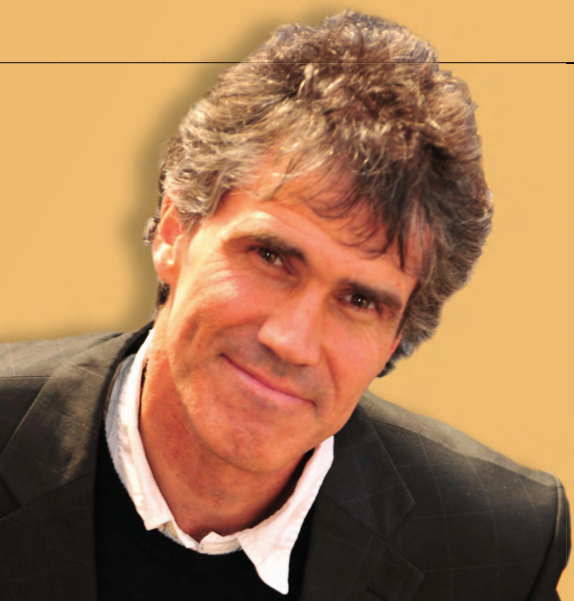
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Taking stock of the options

The director of science and technology at the British Geological Survey hasn't given up on carbon capture and storage. Evelyn Adams reports



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e was part of the team credited with putting carbon capture and storage (CCS) on the government's policy map. But with the UK's CCS plans stalling, Prof Michael Stephenson says we need to take stock of our options for tackling climate change.

The director of science and technology at the British

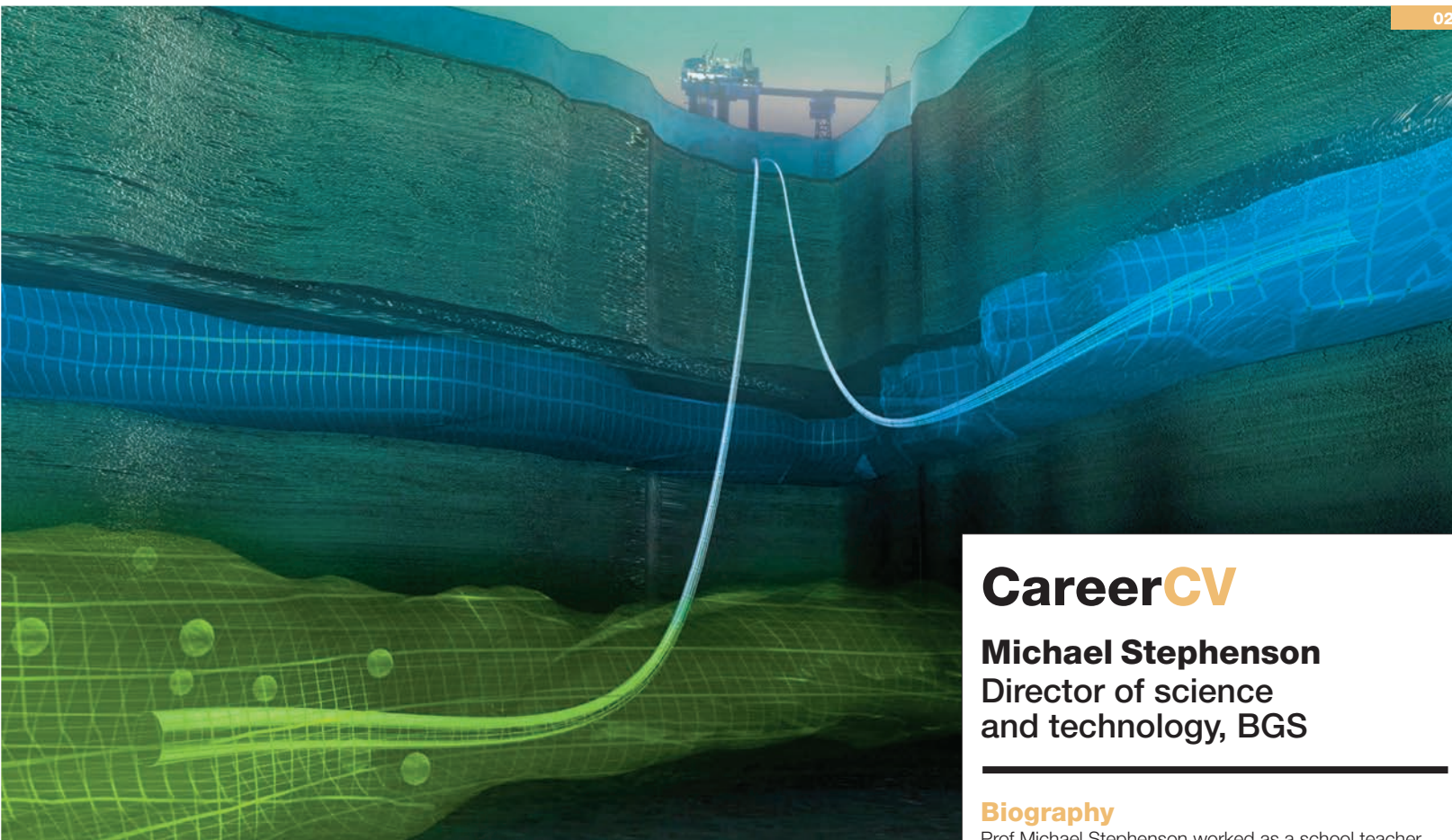
Geological Survey (BGS) cites a recent report by the Parliamentary Advisory Group on Carbon Capture and Storage that found the cost of meeting emissions goals could be reduced if a network of pipes is built to store

CO₂ beneath the North Sea. The report was written on the back of what Stephenson describes as a 'catastrophic' cancellation of the UK's £1bn CCS competition.

He says the technology could buy time for governments to develop electricity storage for renewables by allowing them to continue using fossil fuels. "The report's author is right to point out that CCS can be a way to decarbonise big industry relatively cheaply, probably in the range of cost of other decarbonising activities," says Stephenson. "Geological processes naturally sequester carbon – coal is a massive example of that – and so CCS isn't all that 'unnatural'."

In his current role, Prof Stephenson is responsible for the science at BGS, which includes overseeing 520 scientists and technologists, and about £15m of investment. "I'm particularly interested in the science that will matter five years from now, geological opportunities or problems – trying to see far ahead so that I can guide BGS science."

But this wasn't the position he saw himself in when he graduated from Imperial College. Immediately after his degree, Stephenson trained as a teacher and then went on to teach in rural Africa for nine years. At the age of 35, he decided to do an MSc and was then tempted by a PhD. "I did the PhD very quickly in two years because I was worried about getting a job," says Stephenson. "Probably I'm a bit



of a risk taker because I took a gamble on a new career – which seems to have paid off, so far.”

This risk-taking streak can still be seen today. Despite the lack of investment, Prof Stephenson has long been an advocate of storing carbon beneath the ground to tackle global warming, particularly as a bridging solution to help decarbonise big businesses. In 2010, he co-founded the Nottingham Centre for Carbon Capture and Storage. The centre brings together the talents of the Engineering Department at Nottingham and the BGS centre of CO₂ storage research excellence.

01 Stephenson has long been a champion of storing carbon beneath the ground

02 Statoil's Sleipner platform uses CCS

Today, its remit has broadened and the facility has been renamed the GeoEnergy Research Centre (GERC). Alongside Royal Academy of Engineering research fellow Prof Matt Hall, who is also the director of GERC, Stephenson is developing a multi-borehole test site for studying underground fluid movement in porous rocks. While research such as this is crucial to developing energy policies of the future, Stephenson also believes we should be taking inspiration from abroad.

The BGS scientist highlights the Sleipner gas platform in the North Sea as an inspiring example of CCS. The field produces gas with unusually high levels of CO₂, but the Norwegian authorities want CO₂ levels less than 2.5 per cent in the pipeline that goes to customers. In 1991 the Norwegian government introduced a tax that penalised the release of CO₂ from gas sweetening.

“The company that operates the Sleipner Field – Statoil – obviously preferred not to release the gas and thereby avoid paying the tax, and so a special processing platform, Sleipner-T, was built to separate the CO₂ from the natural gas,” said Stephenson. “Rather than pump the CO₂ separately ashore it investigated the idea of disposing of the gas in rocks about 1km below the seabed but above the gas accumulation. They began this ground-breaking disposal in 1996 and are still injecting today so that more than 10 million tonnes of CO₂ are permanently below the sea bed. This amount is about a year's worth of a big UK power station's CO₂ emissions.”

It will take more than just scientific backing to make CCS a reality in the UK – big businesses need to get on board. “It's difficult to see big CCS investment because it's not a profitable enterprise,” says Stephenson. “As a carbon abatement process, the exchange of coal with methane is more likely because you can make money out of extracting

CareerCV

Michael Stephenson Director of science and technology, BGS

Biography

Prof Michael Stephenson worked as a school teacher for nine years from 1987–1995 in a small rural school in southern Africa. At the age of 35, he made the decision to go back into education and studied for an MSc and a PhD between 1996 and 1998. Between 2008 and 2013, he was director of science (energy) at the British Geological Survey (BGS), in charge of carbon capture and storage, advanced seismic science, renewables, clean coal, oil and gas, and reservoir geology. In March 2013, he was appointed director of science and technology of the British Geological Survey. Stephenson now runs the Science Programme at BGS, the UK's national geoscience and data centre, with 520 scientists and technologists, and has responsibility for a £15m science and technology programme. Stephenson has written a book *Shale Gas and Fracking: the Science Behind the Controversy*, which won an honourable mention at the Association of American Publishers PROSE awards in Washington DC in February.

methane, and because exchange of coal with gas in electricity generation is fairly straightforward. I'm interested in gas as a fill-in for the intermittency of renewables, where power plants adjust their output as demand for electricity fluctuates throughout the day.”

Storing hydrogen deep underground in salt caverns and converting it into a reliable and flexible power source could be one way of using gas to replace coal. Stephenson says he is currently looking into whether the BGS should invest in the science of how hydrogen might be stored in salt layers underneath Britain. What solution the UK chooses is yet to be seen, but this type of applied science, he says, is vital to Britain's energy future. “Science done in organisations such as BGS isn't blue sky, but it's really important to lives and livelihoods.” ☐

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Imagining the future Napoleon

Novelist Jon Wallace considers the science fiction implications of engineering stories that have caught his eye. This month, examining the predicament of the soldier of the future

Super Soldiers are not the easiest subject matter for the science fiction writer in search of heroes. Too many soldiers with too much technology inevitably wield too much power, and consequently fail to gain a reader's sympathy. Overwhelming

strength takes on an oppressive character in the imagination, and armies more often serve as antagonists, stormtroopers whose chief virtue is their faceless abundance; cannon fodder for heroes.

Soldiers find their element in science fiction when they are isolated or set apart from command. Sometimes the storyteller will pick a core group out of the mass, rendering them as rebellious as possible within the conformity that is military service. Their 'super' abilities (usually linked to a retained capacity for spontaneity and initiative) are played up, then knocked down in the face of an unexpected, overwhelming foe – tossing in betrayal for good measure: witness the Sulaco Marines of *Aliens* and the rescue team in *Predator*.

Where a soldier is portrayed in isolation, the story often focuses around a gifted individual – Ender's Game's Ender or *All You Need is Kill*'s Keiji Kiriya – who has unique agency in victory. Others are cut off from command, and compelled to rediscover their humanity, as in 1992's *Universal Soldier*. In other works, such as Joe Haldeman's *The Forever War*, one soldier's experience conveys an anti-war message about the way combat dislocates soldiers from previous lives.

Whatever the case, the writing of military science fiction is a constant exercise in drawing individuals out of the mass. So when *The Engineer* reports on Dismounted Close Combat Sensors (DCCS), which promise to better network the troops of the future, writers might worry that engineers are making our jobs harder. DCCS accurately calculates the position of individual soldiers, even without GPS, and allows them to be tracked in buildings and tunnels. A combination of camera, laser and orientation sensors shares information between wearer and commanders.

What are sci-fi writers supposed to make of



Even in worlds where commanders maintain complete control of their troops, there is still a great deal of potential for stories

this? Any army where commanders are able to share their troops' experience in such intimate fashion leaves very little wriggle room for the outlaw spirit of a Hudson or a Dutch. Might the increasing meshing of grunts to command leave them little more than flesh drones?

Well, perhaps. But on reflection there is ample room for story in the world of the networked future soldier. How will wars be fought if commanders experience the battlefield through closer connection to their soldiers? The slaughter of war would certainly become more immediate.

We might tell the story of a future army of soldiers whose very senses are shared with their commanders. When called to battle the army falls back in disarray, starved of orders, as

"Might the meshing of grunts to command leave them little more than drones?"

Jon Wallace

its commanders are traumatised by an acute networked traumatic disorder – brought about by the shared experience of countless brutal combats. In the absence of generals the army evolves to work more like a swarm, prevailing via a shared, fully co-operative form of decision-making.

Even in worlds where commanders maintain complete control of their troops, there is potential for stories; perhaps drawing inspiration from military history. We could tell the story of a future Napoleon, whose army of obedient super soldiers have realised his strategic genius on a grand scale, bringing countless planets under his yoke. His march is only halted when, landing on some backwater planet, a sudden, brutal winter renders their vaunted technology useless, freezing super weapons; scattering communications and greying out the skies, preventing rescue. Lost in drifts, his army falls into sickness and starvation, picked off by natives who turn the conditions to their advantage. Future Napoleon is finally caught in the thaw and run through with a spear, falling in the most primitive combat imaginable.

Leaving history, what might the present indicate for future soldiers? We live in a world of growing inequality and runaway military costs, where it is not hard to imagine total military privatisation. We could set a story in a world where a caste of oligarchs hire nations' networked, obedient armies to alleviate their personal boredom; competing with them as if they were conkers, waging war from their living rooms.

Yet perhaps there is hope. There is, after all, an air of make-believe to many military engineering stories, the most prestigious projects more boondoggle than wonder weapon. Whether stealth fighters, networked troops or robot soldiers, the idea of a shooting war between the world's major powers is a fantasy.

In that case, might all the technological invention of military engineering be entrusted to single warriors, nations' differences settled by the clash of champions rather than armies? What of a future where the rulers of nations are compelled to strap on the tools of war, to kill or be killed for their countries, while the voters watch from their sofas? ☺

Jon Wallace is a science fiction author living and working in England. His new novel, *Rig*, came out in paperback and ebook in June

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Formula One arms race for all-important marginal gains

Suspension rocker arm gets optimised with the help of CAE. Supplier: GRM Consulting

Computer-aided engineering (CAE) specialist GRM Consulting has helped the Lotus Formula One (F1) team optimise a suspension rocker arm, delivering a marginal gain in a sport where every little counts.

F1 has come to epitomise the convergence of sport and technology, with minute aerodynamic and weight gains translating into tenths of seconds on the track. Whereas in the past, horsepower was the primary consideration, today's rules mean that savings of grams and millimetres can be the difference between topping the podium and getting lapped by the field. As a result, teams across the paddock are looking to optimise virtually every component that makes up today's F1 cars.

In this instance, Lotus used GRM's

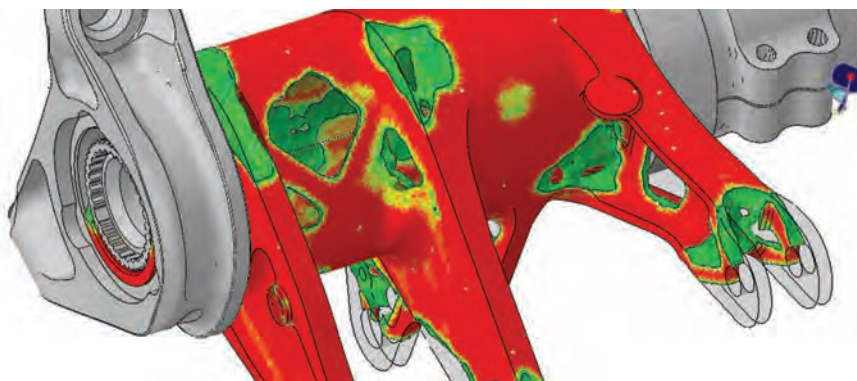
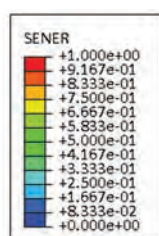
TruForm for Abaqus topology optimisation tool to analyse existing data on the rocker arm. While optimisation is commonly considered a tool to identify new concepts and designs, the Lotus F1 Team applied

TruForm to detailed Abaqus models of mature designs, achieving relatively small but significant mass savings on existing components in their race cars.

One such example of this was a suspension rocker arm that was at

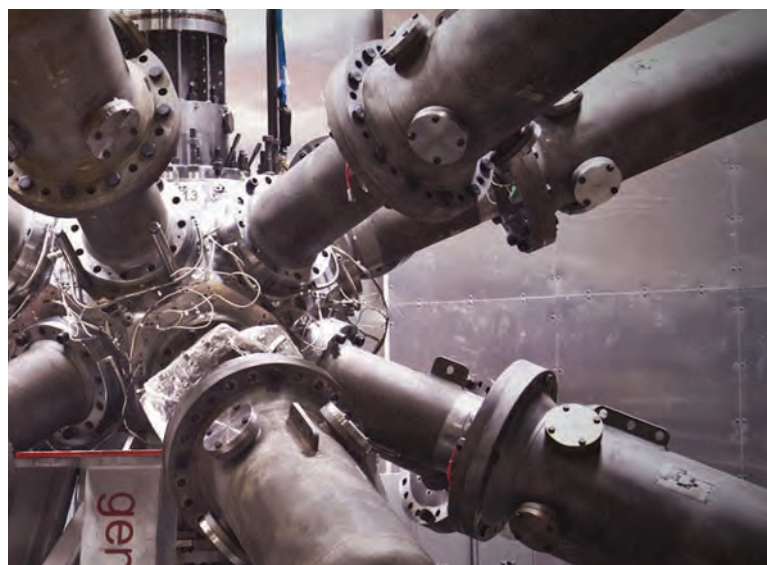
the latter stages of design, with analysis sign-off already under way. With the need to verify the structural performance for nine individual load cases, the rocker arm was assembled into a detailed Abaqus model comprising complex pre-loading conditions, constraints and the interaction to the complete rocker assembly.

With no change to the Abaqus analysis model, a TruForm optimisation was performed overnight, identifying several areas of the component where radii could be increased and weight-reducing holes could be included, adding to those all-important marginal gains on the cars. ☺



Access to simulation is on a more level footing

Start-ups can access products used by big firms. Supplier: Ansys



Ansys has launched a program to give start-ups access to the same engineering simulation products used by established industry leaders.

It has done this because companies trying to gain a foothold in their market often perceive costs associated with engineering simulation as prohibitive.

Consequently, engineers in those companies spend a disproportionate amount of time and money building multiple physical prototypes, or miss effects that cannot be discovered using traditional product development.

The Ansys Start-up Program aims to provide virtually free access to the Ansys suite of engineering simulation products.

One beneficiary is Dr Michel Laberge, who founded General Fusion in Burnaby, Canada to develop economically viable fusion energy.

He realised that Magnetised Target Fusion, with the aid of modern electronics, materials, and advances in

plasma physics, could provide a practical path to fusion power.

The company's Magnetised Target Fusion system uses a sphere filled with molten lead-lithium that is pumped to form a vortex. On each pulse, magnetically confined plasma is injected into the vortex. Around the sphere, an array of pistons impact and drive a pressure wave into the centre of the sphere, compressing the plasma to fusion conditions.

General Fusion's system has three key advantages, namely: a thick liquid metal wall; a compressed gas driver; and no consumables.

At the centre of the magnetised target fusion system is a large liquid metal-filled sphere compressed with pistons. In the engineering design, General Fusion relied on Ansys simulation codes for structural analysis.

Ansys codes enabled General Fusion to simulate the dynamic loading of the structure from pressure pulses generated by 14 large, high-speed pistons. The results of the simulation have been verified against actual measurements from the commissioned machine.

In the next phase of development, General Fusion will be constructing a full-scale prototype system. ☺

Product data management is now all up in the cloud

Fusion Lifecycle software platform enables engineers to collaborate on designs. Supplier: Autodesk

Autodesk has introduced cloud-based product data management (PDM) to Fusion Lifecycle, a development aimed at giving users a complete 'concept-to-market' toolset.

At the heart of the software platform is Fusion 360, which combines CAD, CAM and CAE in the cloud. Earlier in 2016, Autodesk says it bolstered the Fusion platform with Fusion Lifecycle for PLM and Fusion Connect for IoT data management.

The new cloud-based product data management (Cloud PDM) functionality is built directly into Fusion Lifecycle and is available immediately. Cloud PDM enables engineers to collaborate on designs and manage their work-in-process CAD data and documents. Teams can effectively collaborate on designs, track versions and releases, and connect to

manufacturing workflows for more effective sharing of design data.

The new PDM features are claimed to improve collaboration between engineering and the rest of the enterprise, enabling real-time design reviews, viewing and mark-up of 3D files, and connecting key processes for managing Bills of Materials (BOM) and Engineering Change Orders (ECO). All of the new PDM functionality is built directly into Fusion Lifecycle and included at no extra cost to subscribers.

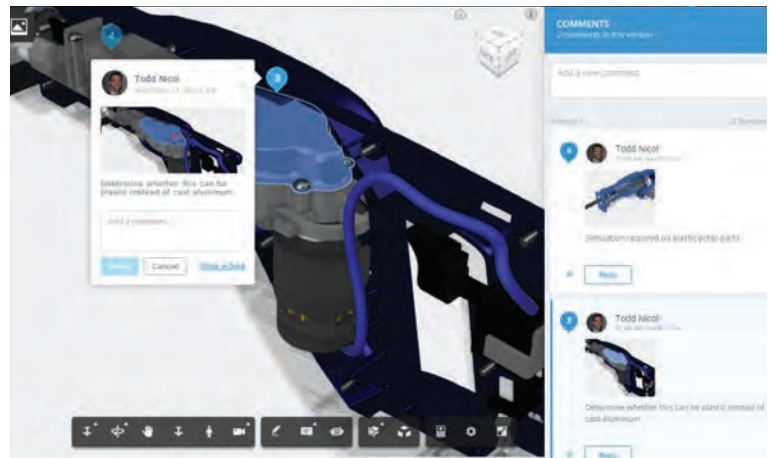
"We have been avid users of Fusion Lifecycle for over a year, and it has greatly improved our product development process. Albeit, this is the piece we've really been waiting to utilise. The full PLM solution, in the cloud, will dramatically improve our efficiency," said Brian Hunter, quality

control manager of NovaCentrix.

Other additions coming to the Fusion portfolio include Fusion

Connect, which will provide Dynamic Predictive Analytics, powered by technology from Nutionian.

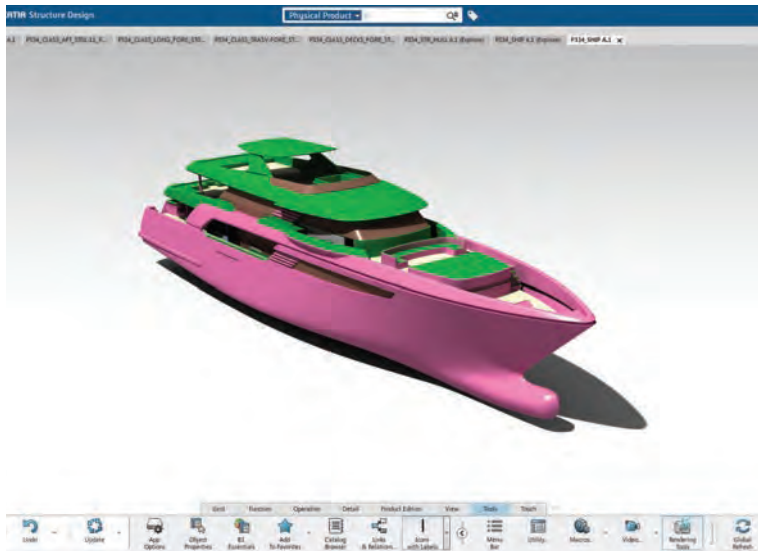
While industrial IoT will comprise 16 per cent of global GDP by 2020, making sense of the unprecedented volume of data is a challenge that typically requires data scientists to derive actionable business insights. Coming as a future option for Fusion Connect customers, Nutionian's Eureka, an artificial intelligence (AI) modelling engine, automatically extracts meaning from large data sets and delivers prescriptive solutions. ☐



Superyacht design is a matter of combination

CAD platform can deal with increasing complexity of modern boat design. Supplier: CAD Dassault

Image: Courtesy Dassault Systèmes



Italian ship and boat designer NAOS will use a combination of products based on the Dassault Systèmes 3DEXperience platform to virtually design and manage the master reference of a superyacht.

With the ever-increasing complexity of modern boat design, managing the interacting systems on board a vessel can be a difficult task. NAOS will use the Dassault Systèmes 'Designed for Sea' and 'Optimised Production for Sea' to integrate all design, engineering, and manufacturing processes in a virtual environment that enables collaboration.

Ships are increasing in size and integrating more energy-efficient equipment, as well as automated and connected systems. In parallel, safety and environmental regulations are

impacting their architecture. NAOS wanted to facilitate the numerous design changes that are typically requested by shipyards and ship owners during the complex project development process.

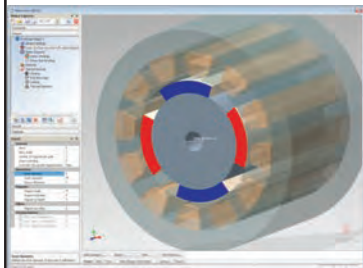
"We have used various shipbuilding CAD systems in the past to develop superyacht projects for shipyards, but wanted a new, more efficient approach that a business platform provides," said Roberto Prever, president of NAOS.

"Designed for Sea' and 'Optimised Production for Sea' make it possible to seamlessly decide on design changes related to stability, basic design, advanced structural design, or safety. Now, we can deliver a project's entire design and engineering much more efficiently. In addition, the integration of manufacturing documentation gives our shipyard clients significant advantages to optimise their production and assembly costs."

According to Dassault, NAOS will be able to capture and reuse existing data, handle design changes rapidly, start planning manufacturing early in the design process, and deliver documentation for hull structure scantling and fabrication, as well as for systems design and installation. ☐

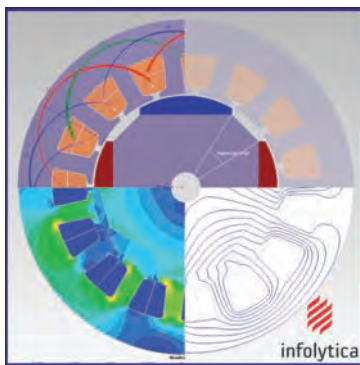
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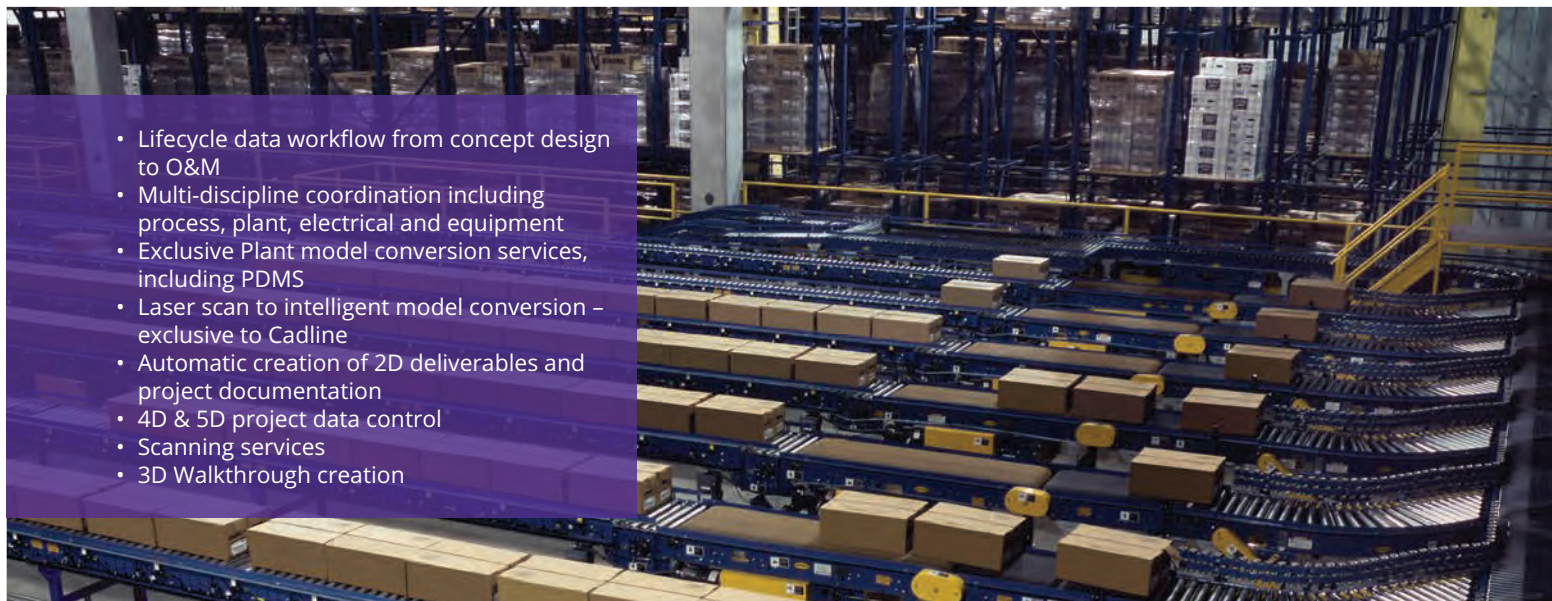
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Robust range of dry claw vacuum pumps emerges

Suited for applications that include pneumatic conveying and woodworking. Supplier: Atlas Copco

Atlas Copco has announced a new range of dry claw vacuum pumps, incorporating a modular design that it says will increase robustness and efficiency.

Suited for applications including pneumatic conveying, woodworking, drying, sterilising, thermoforming and extrusion, the DZS range comprises three models: the DZS 065V, DZS 150V and DZS 300V. With nominal displacements of 45, 90 and 180cfm respectively, the DZS pumps offer vacuum levels ranging from 50–140mbar(a), 28.3–25.8 Hg Vac.

According to Atlas Copco, a significant feature of the DZS modular concept is the segregation of the corrosion-resistant pumping chamber from the gearbox. This allows easy access for the removal, cleaning and re-assembly of the stainless

steel claws, while at the same time eliminating the need to strip and re-time gears after cleaning procedures. The isolation of the gearbox removes the risk of contamination from process or gearbox oil that occurs with more traditional pump technologies.

The vacuum pumps are powered by VSD-compatible IE3 motors, designed to provide a smooth and efficient flow throughout the complete speed range. Atlas Copco says the VSD units bring energy savings of up to 50 per cent compared to their

fixed-speed equivalents. These drives not only match response to varying demand, but also provide the opportunity to

replace multiple machines with single units, making it possible to centralise pumps in one location and optimise system performance.

The company claims the DZS modular design also offers major advantages with heat dissipation issues. Traditional claw pumps run hot, which can adversely affect seals and bearings, causing premature failure. But by using upgraded bearings and seals, in combination with a patented cooling design, Atlas Copco believes the new range will deliver quiet air distribution and smooth operation. ©



Internal gear pump is more easy on space

Able to be driven by standard electric motors. Supplier: Viking

Viking has launched a new internal gear pump that can be driven by standard electric motors, removing the necessity of a gearbox and providing a smaller footprint.

The Viking Motor Speed can run at either 720, 960 or 1,450rpm, delivering increased flows that can provide more cost-effective pumping in less space. The range includes models which provide flows up to 88m³/h at standard motor speeds, or 132m³/h when users do opt to use speed reducers or gearboxes.

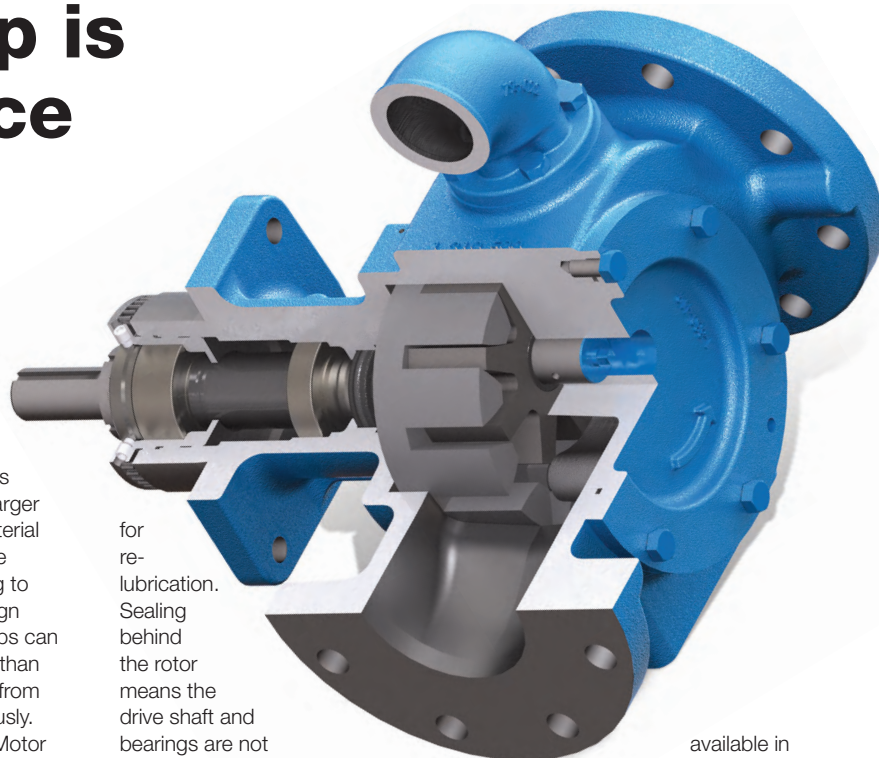
Typically used for transferring refined fuels such as diesel and biofuels, as well as crude oil, hydraulic oils, chemicals and solvents, the Motor Speed includes a pump head with idler and rotor speed grooves to improve axial feed, a liquid directing

step to reduce turbulence, a modified crescent to boost radial feed, and improved port geometry to optimise flow paths.

The pump's rotor profile has also been increased and, on larger models, the standard idler material is hardened steel to reduce the effects of cavitation. According to Viking, the result of these design improvements is that the pumps can be operated at higher speeds than before, delivering greater flow from a smaller footprint than previously.

Other features of the new Motor Speed Series include a pressure lubricated idler pin and bushing to enhance the component durability, as well as sealed, anti-friction bearings that eliminate the need

for re-lubrication. Sealing behind the rotor means the drive shaft and bearings are not exposed to the pumped material, and a threaded one-piece bearing housing allows for easy end clearance adjustment. The Motor Speed pumps are



available in close-coupled and long-coupled drive options for motor speed operation, and with gearboxes when operators require reduced speed. ©

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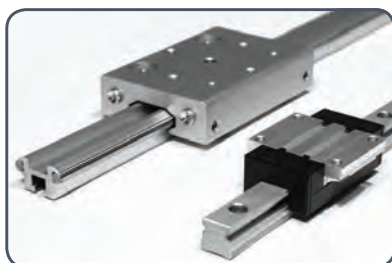
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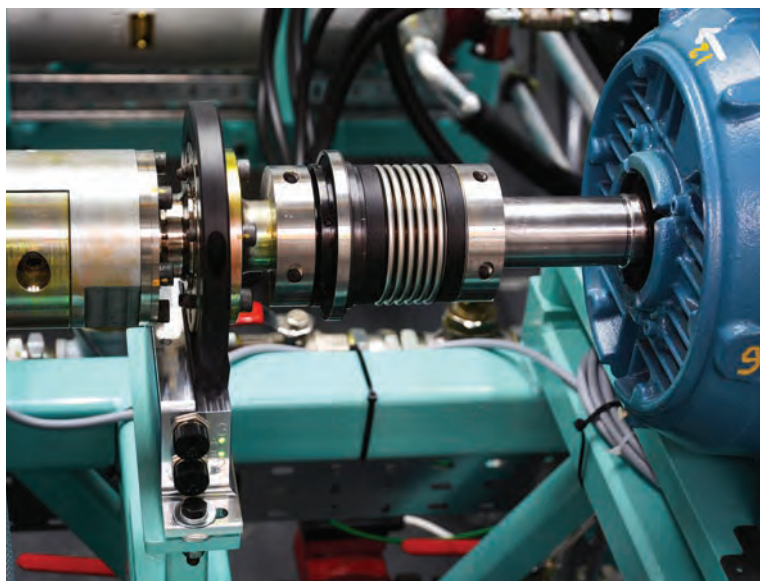
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Compressor operates in a continuous cycle

Geometry and technology of Blade Compressor is different to traditional systems. Supplier: Lontra



The global market for air compressors is £25bn, yet there have been few new innovations in the industry for over 80 years.

Step forward Lontra, whose Blade Compressor – unlike the traditional piston and cylinder design that has to stop and change direction – operates in a continuous cycle, inducing air behind and compressing air in front.

The geometry and technology of the Blade Compressor is very different to traditional compressor systems so Lontra had to consider multiple factors during the design process. Of particular importance were the bearings to reach the desired motion and reduce friction.

Due to the continuous high speed that compressors run at, Lontra required a solution to minimise thermal energy and noise emissions.

SKF bearings provided a number of performance benefits that ensured efficiency was not compromised. Lontra and SKF worked together to analyse the bearing arrangement and establish the optimum pre-load to achieve optimal service life.

The roller bearings were specified and installed into the test rig at Lontra's Technology Centre in Napton. Lontra has since delivered maximum efficiency thanks to high load-carrying capacity, low-operating temperatures and exceptionally low vibration and noise levels. Compared to other compressors, the Blade Compressor offers a far longer service life.

Severn Trent Water was one of the first to pilot Lontra's compressor and undertook a seven-month site trial at its Worcester facility. The results demonstrated 21 per cent energy savings with the potential to deliver a 3 per cent reduction in annual energy costs for the entire business.

Identified as major energy users, air compressors are coming under increased scrutiny as new regulations are in preparation by the US Department of Energy and the EU (under the EcoDesign Project Lot31). These new regulations are anticipated to drive the adoption of more efficient compressors. ©

A definite reaction post-Fukushima

Pumps can operate in a complete station blackout. Supplier: SPX Flow

SPX Flow has designed, developed and manufactured a new generation of turbine-driven cooling pumps for many of the world's nuclear facilities as they come back on line following the incident at Fukushima.

Produced by SPX Flow's Glasgow-based ClydeUnion pumps facility, the TWL pump (Turbine Water Lubricated) is designed to ensure emergency reactor cooling in the event of a complete station blackout and can function when fully submerged in water.

The TWL has been designed specifically to respond to the needs of the post-Fukushima nuclear industry featuring a compact design, simplified turbine controls and reduced maintenance requirements. Significantly, the

TWL has the ability to operate with no external electrical power.

Fundamental to the TWL operation is the mechanical governor and throttle mechanism, requiring no electrical power or pneumatics, as well as a product lubricated bearing system that eliminates the need for an oil system and associated controls.

The discharge branch of the pump incorporates a venturi, a flow measurement device fitted in the discharge that is used to monitor flow and pressure. It communicates with the steam side to control the pump and provides a pressure signal proportional to pump flow.

The pressure governor converts this 'signal' into mechanical action that acts on the throttle mechanism and controls the steam flow to the turbine.

As there are no electrical speed control devices involved, the TWL starts rapidly on admission of steam and reaches its operating speed in under 10 seconds.

The design can accommodate water slugs in the steam line, both at start-up and while running with no detrimental effect to the equipment and only momentary interruption of pump performance.

The enhanced safety features integrated in the TWL pump offer firm evidence of the focus on safety with this product. ©



More than one discipline

Precision machining and metal 3D printing is now on offer from a single source



firm offering precision machining and metal 3D printing has been created following the merger of Newbury-based Progressive Technology and Birmingham's Innovate 2 Make (i2M).

The deal, completed in September 2016, means the creation of a company

offering low- to medium-volume production of complex components used in high-performance environments.

It will give Formula One (F1), aerospace, and medical clients greater control of quality and reduced lead times when developing products that require both disciplines.

The new business will be called Progressive Technology — Advanced Manufacturing and is targeting more than £2m of additional sales in its first 12 months.

"The merger is a natural progression of a working relationship that has been in place for a couple of years now," explained Ross Pinchin, managing director of Progressive Technology.

"We have a number of shared customers who use us to manufacture parts for F1, with i2M providing the metal 3D-printing expertise and our multi-axis machining capability delivering the secondary operation."

He continued: "By bringing the two firms together we've

created — what we believe — is the largest single-source full-service machining and metal 3D-printing solution in the UK."

Mike Kelly, director at Innovate 2 Make, said: "When we first started talking about 3D printing, or additive manufacturing as it is sometimes known, it was about replacing traditional manufacturing processes.

"That's no longer the case, as on its own it just doesn't meet what customers are asking for. It is an extremely valuable discipline for manufacturing short-batch, complex parts, but will always require secondary operations, such as CNC machining, to give you the tolerance or finish you are after.

"This is why this merger is so exciting. We can now offer the end user a complete service, from using metal 3D printing in the initial production of the component to tapping into Progressive Technology's fantastic capabilities in Newbury.

"The latter includes a bank of 5-axis CNC machines, two-wire EDM machines, wire and spark eroders, state-of-the-art milling and one of the largest inspection and quality assurance departments ever seen in a SME."

Established in 1977, Progressive Technology has grown from a small toolmaking business into a supplier of components to F1 teams, supplying 80 per cent of the grid.

The company, which operates 24 hours a day, seven days per week, has invested more than £2m this year in its machining and composite centre in Hambridge Lane.

This approach has seen sales rising to £6.8m in 2015 and expected to reach £9m by the end of this year.

Birmingham-based Innovate 2 Make has enjoyed a similar period of growth after launching in 2012.

Led by Mike Kelly and Ian Campbell, the firm has transformed a

Indepth

New cluster looks to tap into demand for OEM strategic outsourcing



The Manufacturing Assembly Network (MAN) is looking to target more than £5m of new contract opportunities after launching a new cluster to tap into the demand from larger companies for greater levels of strategic outsourcing.

Mec Com, PP Control & Automation and SMT Developments have joined forces to give original equipment manufacturers (OEMs) the chance to access fabrication, electronic and electrical assembly services through a single source.

It comes after the trio saw a 25 per cent increase in the number of outsourcing 'wins' secured over the last 12 months and will provide a new dedicated resource for clients looking to outsource non-core activity, while investing more resource on critical manufacturing operations.

By sharing its resource, knowledge and expertise, the cluster hopes to reduce customer lead times, increase capacity and reduce overall production costs.

"Every year we set out a 12-month strategy for growing the MAN Group and this time we decided to focus on splitting into clusters to target specific customer groups," explained John Rowley, managing director of electronics manufacturing specialist SMT Developments.

Other member companies include Alucast, Barkley Plastics, Brandauer, Grove Design, Kimber Mills International and Muller Holdings.

unit in Kings Norton into a metal 3D-printing centre.

It is one of the few businesses in the country to have access to two EOS M280 400W laser melting platforms, along with full materials laboratory and inspection unit.

Progressive Technology — Advanced Manufacturing will use the combined capacity to secure additional work in F1 and to open doors into new markets, such as automotive, aerospace and renewables.

It has already taken measures to make inroads into the cycling sector, with Campbell leading on the launch of Mirada Performance Products, a spin-out company delivering design and production-grade components.

By combining metal 3D printing with multi-axis machining it is able to produce highly engineered lightweight parts, while eliminating cost-intensive tooling. This is suitable for using new materials to create bespoke bike frames and associated components. ☐





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Shifting the gender perspective

A new study is investigating why female engineers are significantly more prominent in some Muslim countries than in the West. Andrew Wade reports

The very fact this magazine regularly publishes a Women in Engineering supplement is symptomatic of a problem that stubbornly persists. Despite the best efforts of many figures both inside and outside the engineering industry, female participation in the sector as a whole remains at embarrassingly low levels in the UK. A recent report, carried out by the Centre for Economics and Business Research (Cebr) on behalf of the Royal Academy of Engineering (RAEng), ranked the UK 58th of 99 for gender parity, behind countries including Brazil and Greece. Statistics from EngineeringUK show that the UK has the lowest proportion of female engineers across the whole of Europe, with just 9 per cent. According to UNESCO data from 2013, women make up just 22 per cent of engineering graduates. The statistics are simultaneously unsurprising and depressing, and the underlying issues are familiar.

"The UK has a disproportionately low share of women who study STEM subjects to 18," Dr Hayaatun Sillem, deputy CEO and director of strategy at RAEng, told *The Engineer*. "Only around 20 per cent of A-level physics students are girls, for example, a percentage that has not changed significantly over the last 25 years."

The problem is by no means confined to the UK. Failings here are mirrored in the US, where, despite widespread programmes to involve more women in engineering, participation rates have been virtually static for more than two decades.

"In the US since 1993, it has only increased the share of women undergraduates in engineering by 3 per cent," said Dr Julie A Kmec, a sociology professor at Washington State University (WSU).

Rather than resorting to the introspection that so often accompanies this issue, Kmec and her colleagues are now looking outwards. In an effort to find solutions to the gender imbalance at home, new research is under way to examine how other countries are getting it right. And many of those countries have predominantly Muslim populations. Specifically, the study is looking at Jordan, Malaysia, Saudi Arabia and Tunisia.

"The high GDP countries in the Gulf tend to have female representation up to 60 per cent in fields such as electrical engineering, computer engineering, chemical engineering and bioengineering," said Dr Ashley Ater Kranov, a professor at WSU's School of Electrical Engineering and Computer Science.

A prominent member of the research team, Ater Kranov also has an academic role at Princess Nourah bint Abdulrahman University in Riyadh, Saudi Arabia, and has been studying the phenomenon of high participation in predominantly Muslim countries (PMCs) for several years.

01 Women make up over half the engineering workforce in some Muslim states

"Saudi only recently offered engineering as a degree option to women at one public university a few years ago," she said. "However, it has had for years extremely high female representation in computer science, information science and IT. What is interesting as well, is that in my informal conversations with faculty and students all over the Gulf, female students tend to significantly outperform men in these particular fields."

So not only are women participating in STEM subjects in much higher numbers than in the West, they are also excelling. But what are the factors drawing them in and, conversely, driving their Western counterparts away? According to Kmec, there are a variety of interlocking socio-political elements at play.

"We have this sort of 'be happy, follow your dreams' mentality, coupled with a macro-cultural value system... a system of gender centralism, which essentially is this notion that men are good at this, and women are good at something different," she said.

"When I say the word 'engineer' in the US, I think of a man," Kmec admitted, a trace of guilt inflecting her voice. "When you say 'engineer' in some of these





countries, the first thought that comes to mind – especially if you say a chemical engineer – it's not a man.

"Some fields of engineering are actually gender-typed female in these countries, at least more so than here, because they don't involve interaction in public... I know for a fact that in Saudi Arabia, women are highly discouraged from majoring in communications, for example, because that puts them too much in the public space."

While there are undoubtedly social restrictions in some Muslim countries

that could push women towards 'backroom' engineering roles, it's important to acknowledge that these do not apply across the entirety of Islam. In fact, gender equality has long been a pillar of Islamic doctrine, and the religion has a rich history of empowering women through education.

"Although there is a perception that Islam represses women and does not give them the freedom to pursue education, this is far from the truth," said Fatumina Abukar, a biochemical engineering PhD student at UCL who was recently shortlisted

02 Despite the perceptions of some in the West, Islam has a rich history of female education

for a WISE (women in science, technology and engineering) Rising Star Award.

"Science and education have always been very encouraged in Islam. For example, Mariam Al-Ijliliya, who lived during the 10th century in Syria, was employed by the ruler of the city as an astrolabe builder. In addition, one of the oldest universities in the world, University of Qarawiyyin [Morocco] was founded by a Muslim woman, Fatima al-Fihri, before women in the West were even allowed to go to university."

In relation to the high rates of female engineers in PMCs today, Abukar believes there are two key factors at play. First, significant numbers of Muslim countries are either still developing, or are in politically unstable parts of the world. Studying engineering makes sense from a practical standpoint, as it is likely to provide a steady income. >>

"Some fields of engineering are actually gender-typed female in these countries because they don't involve interaction in public"

Dr Julie A Kmec



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>> “Second, in Islam, one is encouraged to pursue careers that will ultimately benefit society, so the population will tend to gravitate more towards professionally designated careers,” said Abukar.

These points are echoed somewhat by Kmec. In the US and the UK, physical infrastructure is not as visibly in need of improvement when compared to most developing nations. It makes sense that if you grow up in a country where there is a clear and obvious requirement for engineers, it’s a career path you’re more likely to follow, both for practical and moral reasons.

“We have a developed economy,” said Kmec. “We have infrastructure, we have roads. In developing countries, the economy does not necessarily allow people to have a choice. In Pakistan, for example, there are limited roads and bridges, and they get washed out every time there’s a storm. And so the infrastructure of countries that are developing... means people go to study what’s important for their country.”

The four countries in the US study were chosen for a variety of reasons, not least due to existing social connections the researchers already have. As mentioned, Ater Kranov has an academic role at a Saudi university, where she spends a substantial part of her time. Kmec’s co-lead on the project, Purdue University’s Dr Jennifer DeBoer, worked across Malaysia and Tunisia for her dissertation. And Dr Nehal Abu-Lail, another WSU engineering professor involved in the research, is a Jordanian national. Incidentally, she comes from a family of six, where all five daughters have become engineers.

A common thread across the four nations is the extent to which their populations practise Islam, with

03 Dr Ashley Ater Kranov, an engineering professor at Washington State University

04 Dr Hayaatun Sillem, deputy CEO and director of strategy at the Royal Academy of Engineering

05 Dr Julie A Kmec, a sociology professor at Washington State University

Malaysia being the one outlier at just 63 per cent. Jordan is 97 per cent Muslim, Saudi Arabia 93 per cent, and Tunisia almost entirely homogeneous at 99.5 per cent. By contrast, Muslims make up just 0.9 per cent of the population in the US, and 4.5 per cent in the UK. According to Kmec, however, there are socio-economic and political variations across the different countries that should enrich the research.

“We didn’t realise until we looked at the information,” she said, “but there’s great variation within these countries in terms of their GDP, in terms of labour force participation of women, their scores on individualism, women’s rights even. Women had the right to vote as early as 1957 in Tunisia, but only in 2015 in Saudi Arabia.”

“The women who participate in the focus groups will answer a quantitative survey, just giving basic demographic background characteristics of themselves. But the whole point is to be able to figure out what women are talking about, and how we can use the information we gather to craft a better quantitative tool that we can apply elsewhere in a survey.”

Ultimately, Kmec and her colleagues aim to shed light on the fundamental issues that are keeping female participation so low in countries such as the US and the UK. By exploring the gender balance of the PMCs in their study, the researchers will hopefully gain some insight into imbalance in the West – an imbalance that persists in the face of significant effort and resource.

“Not much at all has been done to study what we are studying in these target countries,” explained Ater Kranov. “That said, there’s been a ton on what may be the factors to such low representation in the US. However, in spite of investing billions, the US hasn’t been able to make representation any higher, save for at a few schools that have made it a priority.”

Gender imbalance has been the standard in Western engineering for so long that many now view it as a cultural norm. Readers of *The Engineer* occasionally express their exasperation at the amount of coverage the topic receives, believing we should simply accept the status quo and move on. But encouraging more women into the industry is absolutely vital. The long-term health of the industry and even the wider economy are at stake.

“We know that engineering makes a significant contribution to society, so increasing the number of women in engineering is therefore critical to maintaining and improving the prosperity of the UK,” said RAEng’s Dr Sillem.

“Addressing gender diversity will not only help to bridge the skills gap, but could also improve business performance: evidence shows that companies in the top quartile for gender diversity are 15 per cent more likely to have financial returns above their national industry median.”

In an industry already struggling to generate enough skilled professionals to meet demand, it would be madness to willingly accept the shockingly low rates of female participation that currently exist. Shrugging of shoulders and essentially writing off 50 per cent of the population is not an option. On top of this, the economic upshot of gender parity is potentially massive, as Sillem points out.

“If gender parity in engineering graduates was achieved – which would equate to around 36,000 female graduates per year – the UK would climb from 14th to seventh in the Engineering Index, putting it above countries such as the Republic of Korea, Belgium, Finland, and Hong Kong. This would boost UK GDP per capita by 7 per cent, according to the Cebr study.”

Shifting the gender imbalance would have a very tangible impact, not least on the women driving the growth themselves. By looking to the example of the East, let’s hope the West can start finding some answers. ©

“If we had gender parity in graduates, the UK would climb from 14th to seventh in the Engineering Index”

Dr Hayaatun Sillem, RAEng

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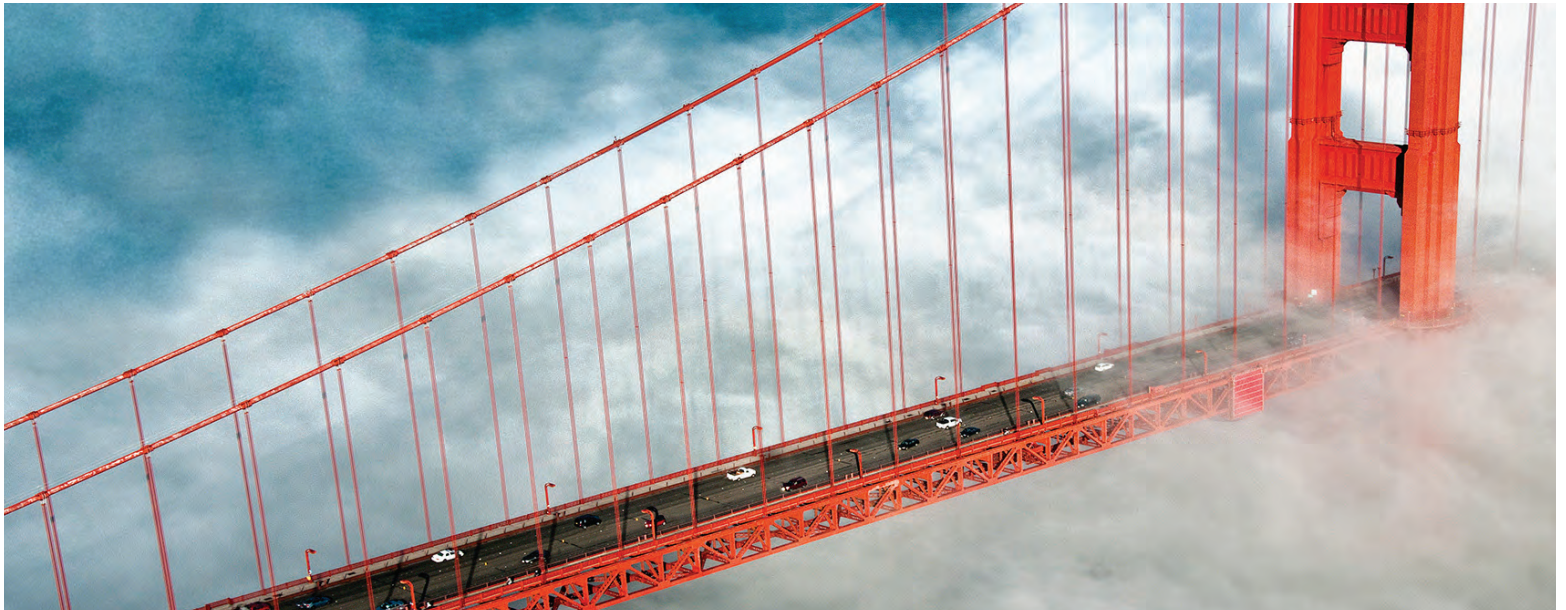
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Managing Industry 4.0

The new head of Festo UK looks back on her career and discusses a lack of young engineers of both sexes. Andrew Wade reports



With 25 years' experience in the engineering and technology sector, Eliza Rawlings has held a wide variety of roles throughout her career. An electrical engineer by trade, she was

recently appointed as the first woman to head up Festo's UK operations, having previously worked for the automation specialist as its national sales manager.

Rawlings initially left Festo in 2010 to become managing director at Cloud Direct, an experience that will no doubt aid her as she leads Festo into the Industry 4.0 era. *The Engineer* caught up with her to hear about her journey into engineering, expanding her management skill set, and how more women can be encouraged to enter the industry.

"I was always interested in the science- and maths-type subjects," she explained. "So that's what I did for A-levels: physics, chemistry and maths."

At her school in Bristol, Rawlings happened to be taking her A-levels just a stone's throw from a local engineering start-up by the name of Renishaw.

"They wrote to all the local schools to see who might be interested in doing some engineering, and I went there during the summer holidays of my lower sixth. Until then I didn't know an awful lot about engineering to be honest, but I was so inspired and so enjoyed my work there. That stimulated my interest in doing a degree in engineering."

Having caught the bug at Renishaw, Rawlings went on to get her BEng in electrical and electronic engineering at Swansea University, with the Gloucestershire firm supporting her studies.

"They actually sponsored me to do my degree, so I went through my graduate training, my sandwich course, and everything with Renishaw," said Rawlings. "It gave me an insight into what real-life engineering was, and it was a very nurturing, fantastic company, even in those early days."

Rawlings had attended an all-girls school, and now found herself as the only woman on Renishaw's inaugural graduate programme. Nonetheless, she said the experience was overwhelmingly positive, and even though the gender imbalance was glaringly obvious, it was never something that made her question her career choice.

"I think if I were to go back in time and start again I would probably still do exactly the same things," she said. "Not that there aren't any preconceptions, but I've never felt negatively treated in any way, or disrespected."



"Change management is about taking people with you, and not just changing processes or strategies"

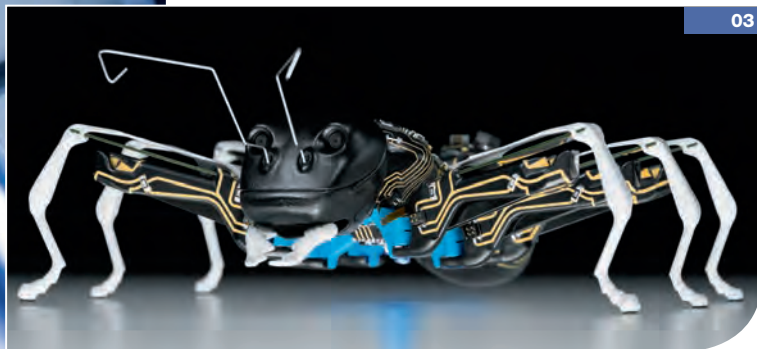
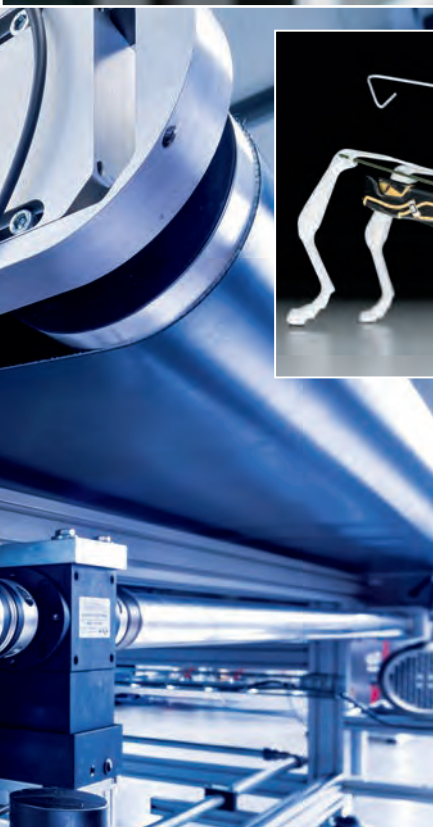
The sentiments chime with those of so many women in the sector who regard engineering as a fantastic profession to choose. But that prevailing positivity inevitably raises questions as to why more women don't opt for engineering as a career. For Rawlings, there was never any doubt. Later in her career she would return to university to gain a master's degree in management learning and change, something she feels has helped her substantially in her various roles.

"[The course] was much more about the people side of organisations, rather than just the business side," she explained. "At that point I had quite a lot of business experience, so it was really... knowing that to be effective as a leader you have to get to grips with the people side. Change management in business is about taking people with you, and not just changing processes or strategies."

As mentioned, Rawlings' initial time with Festo saw her head up the company's national sales team. It's a role that would shape her approach to leadership, providing a first-hand understanding of the



02



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01 About 8 per cent of Festo's revenue goes back into R&D

02 Digital technology is becoming embedded in almost all industrial processes

03 Rawlings is excited about Festo's developing bionics network

challenges faced by manufacturers on the ground. But before returning to the company as the UK general manager earlier this year, Rawlings spent six years in charge of cloud services provider Cloud Direct. Rawlings' time there enhanced her understanding of the fundamental shift that industry is facing, as digital technology becomes embedded in virtually every process.

"My experience at Cloud Direct has clearly exposed me to what type of cloud is safe, and what is not," said Rawlings. "Like anything, it depends on who you buy from... I think my understanding of the whole security aspect will help our customers to gradually embrace the challenge of cloud rather than fear it."

According to Rawlings, the industrial cloud has some way to go before catching up with consumer and business iterations, and wider buy-in will be required before it reaches maturity. Elsewhere, Festo continues to invest heavily in R&D, pumping around 8 per cent of revenues into automation innovation. Given her background, it's an aspect of the business that remains close to Rawlings' heart.

"Being an engineer, obviously innovation still makes me smile," she said. "I feel particularly excited about our bionics network, the lessons from nature... to develop bionics for maybe the future of robotics and factory automation... every time I look at those videos it's just an inspiration."

Improvements in manufacturing are delivering innovations that may be less spectacular than Festo's bionics programme, but certainly no less important. Rawlings gives an example of a valve that is price-competitive with a Chinese equivalent, yet maintains a high level of quality through marginal gains in materials and processes.

CareerCV

Eliza Rawlings Managing director, Festo UK

- Began her engineering career at Renishaw while studying electrical and electronic engineering at the University of Wales, Swansea.
- Later in her career attended the University of Bristol where she received a MSc in management learning and change.
- Between 1997 and 2002, she headed the sales and marketing unit at Baldor Electric, a member of the ABB Group.
- Subsequently joined Festo, where she would initially spend eight years as national sales manager.
- Left Festo in 2010 to become managing director of UK cloud services company Cloud Direct.
- Returned to Festo in April 2016 to take charge of the company's UK operations.

"Rather than do what a lot of other people do – which is just move to a low-cost manufacturing country – we can actually maintain manufacturing in what would be perceived as high-cost countries, but being price-competitive through innovations in manufacturing processes."

This approach is one factor that has enabled Festo to maintain the bulk of its production plants in Europe, with its St Ingbert-Rohrbach facility in western Germany still the company's biggest. For the UK, however, the familiar issue of skills shortage continues to be an issue.

"The UK engineering skills gap is always a challenge," said Rawlings. "In addition to looking for experienced engineers, we've got our own apprenticeship programmes, bringing in young talent and nurturing them through our learning programmes. Obviously it's not just us. Anybody working in UK engineering will find the skills gap a real challenge to get the right people on board."

Naturally, part of the solution must involve widening the appeal of engineering across both genders, strengthening the overall pool of talent at source. But despite substantial efforts to redress the gender imbalance, girls are still turning away from STEM at A-level, and female representation in engineering remains relatively static.

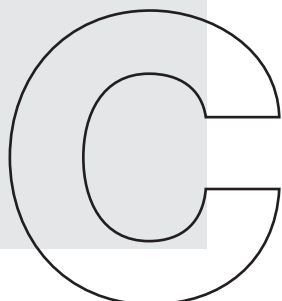
"I went to Renishaw back in the 1980s and I don't know if the situation is any better now," Rawlings said. "We need to appeal to both genders. Obviously we're not getting enough girls, but I think we're also not getting enough boys."

"I think schools... are very under-informed about what engineering is, and we have a role to educate them. [Engineering is] such a diverse subject. It's really hard to grasp what an engineer does... my own daughter told me a lot of girls don't choose engineering, because they simply don't know what it is."

With women like Rawlings increasingly visible at the top level of industry, one can be hopeful that perceptions of engineering will continue to evolve. ■

Winners emerge at new awards event

Cross-disciplinary collaboration was celebrated at the finals of *The Engineer's* inaugural Collaborate to Innovate (C2I) awards



Collaborative engineering projects ranging from the design and construction of the UK's largest-ever warship to the use of 3D-printing technology for surgical implants were among the winners announced at *The Engineer's* new awards event in London on 7 September.

Judged by a panel of leading UK engineers – and sponsored by Frazer-Nash Consultancy and Yamazaki Mazak – winners had to demonstrate innovation, collaboration and that they were likely to have an impact in their field.

The event – attended by an enthusiastic audience of around 200 engineers from across academia and business – provided a fascinating snapshot of some of the trends and technologies that are defining modern engineering, and also highlighted the degree to which industry and academia are collaborating to solve fundamental problems across many sectors.

Commenting on this year's winners, C2I judge and Rolls-Royce Research and Technology director Paul Stein said: "These awards encourage a flow of excellent ideas and examples, showing how industry and academia are working together to create a profitable future for us all." Fellow judge, EPSRC deputy CEO Prof Tom Rodden added: "These awards illustrate the strength, breadth and depth of collaboration between academia and industry in engineering, and the impact they have on society and the economy."

The winners, listed in full on this page, will present their projects at *The Engineer's* Collaborate to Innovate Conference, which will be held on 17 November at Coventry's Manufacturing Technology Centre.

Delegates to the conference will learn about the manner in which the UK's most successful engineering collaborations are managed and hear about the cutting-edge technology innovations that are taking place across the UK's different engineering sectors.



Jon Excell addressing the event on 7 September

As well as helping delegates understand how to effectively project manage collaboration between multiple partners, the event will also provide some valuable insight and practical advice on how to work effectively with specialists from other disciplines and sectors.

Alongside this, delegates will also hear from a panel of industry-leading keynote speakers who will highlight some of the disruptive technology trends that will hopefully help to transform the industrial landscape.

Keynote speakers include legendary Formula One engineer Prof Gordon Murray, who will be talking about his iStream manufacturing process; Airbus UK technology chief Mark Howard, who will give some fascinating insight into key aerospace developments; and Stratatsys vice-president of strategic consulting Dr Phil Reeves, who will examine how industrial collaboration is driving the development of 3D printing. ©

To find out more and to register, visit conferences.theengineer.co.uk

The winners

Category: Energy, Efficiency & Sustainability Sponsored by ABB
Atmospheric sampling over Ascension Island using UAVs
University of Bristol with the University of London, University of Birmingham, Royal Holloway University
 The development and use of autonomous drones to collect high-altitude atmospheric samples.

Category: Health & Wellbeing Sponsored by GE
ADEPT – additive manufacture for design-led patient treatment

Renishaw PLC with PDR, Abertawe Bro Morgannwg University, LPW Technology Ltd
 Initiative aimed at enabling widespread use of 3D printing to produce bespoke implants.

Category: Information, Data & Connectivity Sponsored by Bosch
ORCHID: The science of human-agent collectives
University of Southampton with University of Oxford, University of Nottingham, University of Southampton, BASE Systems, Rescue Global, Secure Meters
 Project examining how humans and intelligent software can work together more effectively.

Category: Safety & Security Sponsored by QinetiQ
The Queen Elizabeth Aircraft Carriers
The Aircraft Carrier Alliance with BAE Systems, Thales, Babcock, Ministry of Defence
 The design and manufacture of two 65,000-tonne aircraft carriers, the largest warships ever built by the UK.

Category: The Built Environment Sponsored by Bechtel
SPECIFIC innovation and knowledge centre
Swansea University, Tata Steel, NSG, BASF, Cardiff University
 Innovation Centre aimed at exploiting the use of smart materials to turn buildings into power stations.

Category: Transportation Sponsored by Airbus
Materials strategic partnership
EPSRC, Rolls-Royce, University of Cambridge, University of Swansea, University of Birmingham.
 Collaborative partnership aimed at producing new materials for use on jet engines.

Category: Young Innovator Design Sponsored by Renishaw
Nine Elms to Pimlico Bridge design project
Watford Grammar School for Boys, Hyder Consulting
 Design concept for a new pedestrian-cycle bridge across the Thames.

Category: Young Innovator for Practical Application Sponsored by Renishaw
Nuclear crane zoning system
Future Tech Studio, Sellafield
 Automated system for controlling movement of crane used to deal with nuclear waste at Sellafield.

Next-generation talent-spotting

UK employers have the opportunity to attract some serious talent at The Graduate Engineer Show in Derby



01

Returning for the fourth year to the Roundhouse in Derby, The Graduate Engineer Show will again provide the UK's leading employers in the engineering and manufacturing sectors the opportunity to attract the next generation of engineering talent.

With more than 1,000 engineering students from over 50 universities, colleges and sixth forms attending the event, The Graduate Engineer Show has become a firm fixture in the calendar and the largest dedicated engineering careers fair in the UK.

The show will welcome many of the UK's outstanding engineering employers including Rolls-Royce, JCB, Severn Trent, Thales, BAE Systems, Balfour Beatty, Jaguar Land Rover, and many others.

Ken Davies, co-director of GSE Media, the event's organiser, said: "The engineering sector is seeing strong growth and this is expected to continue. With no sign of a downturn in needs in the post-Brexit referendum era, the demand for new talent in this area continues to out-strip supply. We have been thrilled by the interest we have received so far from both engineering companies and engineering students, and it promises to be a very busy and exciting day."

The event is being organised by GSE Media, a Derby-based events business, and is being staged on Wednesday 26 October.

Interest in The Graduate Engineer Show this year is particularly high, and the event will showcase the Bloodhound SSC, the supersonic car designed to go faster than 1,000 mph, and will be welcoming its project director, Richard Noble OBE, as a guest speaker.

Commenting on the event, David Reeks, co-director of GSE Media and organiser of The Graduate Engineer Show said: "The Graduate Engineer Show continues to provide an excellent opportunity for those interested in developing a career in the engineering sector to meet prospective employers and learn about the outstanding career opportunities the sector can provide. The event seems to get bigger and bigger each year."

"Derby's Roundhouse, with its rich engineering heritage, is the ideal venue for the show, which has become very firmly established in the calendar for engineering employers." ©

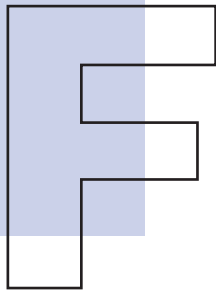
01/02 Derby's Roundhouse is set to play host to some of the UK's leading engineering companies



02

Four shows are rolled into one

Advanced Engineering will span key industry sectors and offer comprehensive access to over 700 organisations



Featuring four shows in one, Advanced Engineering will span key industry sectors, including aerospace, automotive, motorsport, marine, civil engineering, performance metals and composite materials.

Visitors will have access to over 700 organisations, many of whom will be using the show to launch new products and services to the wider engineering market. There will also be a comprehensive conference programme with sessions from organisations including Jaguar Land Rover, Innovate UK, Magna International, SMMT, BOC, KTN, National Instruments and the Women's Engineering Society.

The conference will also include on-floor feature displays of some of the world's leading engineering projects, giving visitors access to latest industry innovations. Features will include a showcase of the winner's projects from the Sapa-sponsored Young Designers Competition, which encouraged UK university students to work with aluminium to exploit its design capabilities.

With the UK's automotive sector continuing to go from strength to strength Automotive Engineering offers numerous opportunities to do business and find the very latest technologies from leading automotive suppliers. Visitors will be able to see presentations from companies such as Jaguar Land Rover and Magna International, plus have access to big-name exhibitors such as SMMT, High Value Manufacturing Catapult (HVM), North East Automotive Alliance, MIA (Motorsport Industry Association) and National Instruments.

Aero Engineering will feature a plethora of key industry suppliers and research institutes, many of whom are committed to finding new developments and innovations within the aerospace industry, including aero structures; power plants; R&D; materials and production.

Planned sessions taking place at its dedicated conference include presentations from ADS, North West Aerospace Alliance, British Institute of Non Destructive Testing, HVM Catapult, RAPRA, ATI, National Aerospace Technology Programme, National Physical Laboratory and many more.

Performance Metals Engineering is one of the fastest-growing areas and covers an area of industry worth £2.6bn a year to the UK economy.

"The total global composites market is estimated to be worth £80bn"

The show provides the latest information for those involved in casting, extrusion, stamping and forging processes. Plus, it also caters to the areas of powder metallurgy, friction drilling, sheet forming processes, metal surface engineering and many more.

The total global composites market is estimated to be worth £80bn and, in the UK alone, the market for affordable composites, for just the automotive industry, is predicted to grow to over £3bn by 2030, demonstrating the magnitude of this sector. So for those interested in the ever-changing world of advanced materials, the

Composites Engineering Show will highlight breakthroughs in composite materials, the most up-to-date equipment used to produce the composites and the research and development that takes place.

The event will host an array of exhibitors, including Composites UK, PREA, Swift Composites, NetComposites, Irish Centre for Composites Research (IComp), EPM Technology, Scott Bader and Gazechem Composites UK. Presentation themes that will be covered include large structures, nanocomposites, sport and leisure, thermoplastic composites and affordable composites.

The show has attracted more than 80 industry bodies, associations and organisations, many of whom will be hosting content-rich conference programmes and seminar sessions. Numerous supporters will also be exhibiting at the show, providing networking and business opportunities for all those in attendance. These include The Institute of Mechanical Engineers, The Aluminium Federation, The European Powder Metallurgy Association, The Engineering Integrity Society and GTMA.

The IMechE will be running its two co-located conferences: Aviation Aerodynamics 2016, and Brakes 2016.

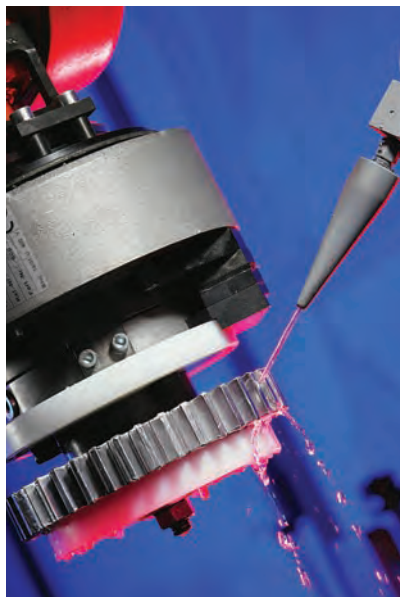
The Aviation Aerodynamics conference, taking place on Wednesday 2 November, will give visitors an opportunity to explore the latest developments and network with specialists in aircraft manufacturing, testing and design. A series of key topics will be addressed by leading experts in the field, including Airbus, The European Space Agency, Reaction Engines, QinetiQ and Rolls-Royce.

On Thursday 3 November, the Brakes 2016 conference will present an opportunity to learn from leading vehicle OEMs and senior-level experts about key engineering solutions for the integration of new technologies and braking systems.



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Evelyn Adams reports

ambitious civil engineering projects in recent years. British engineers have not only embraced these challenges, but have become world leaders in the field. Today, the UK has one of the safest and most reliable railway networks anywhere in the world. Fiona Fitzgerald, a representative at Arup, said that this is reflected in the fact that British engineers are some of the first in the world to engage with the latest developments in areas such as driverless trains, digital signalling systems, track monitoring, cloud technology and 3D modelling.

As a result, Britain has some of the most talented rail engineers in the world. Andrew Boagey, vice-chair of the Railway Civil Engineers Association said British engineers can sometimes underestimate the value of their engineering skills abroad. "People love to have Brits in the mix and genuinely trust our reputation for fair play," he added. "We come across as more collaborative and less arrogant than some others, but we should beware of stereotypes. It is so much easier to work in a multinational environment if English is your first language."

Other projects such as the Channel Tunnel, High Speed One, St Pancras railway station and the Jubilee Line

Britain is a country built around railways. Since the opening of the legendary Stockton and Darlington line on Teesside in 1825, rail infrastructure has been an integral part of the nation's development. Today, the rail industry plays a key role in the nation's economy, contributing around £9.3bn each year. Nearly one in five

European passenger journeys take place in the UK, giving the nation the fastest-growing rail network in Europe.

But keeping up that growth requires skill. Much of the network in Britain is buried deep within the urban environment that makes maintenance and renewals complex tasks. As well as this, the UK has several regional systems that developed when the railways were originally conceived. "This presents technical challenges that do not exist in many other countries," said Ailie MacAdam, global rail sector lead at Bechtel. "A good example of this is Crossrail; this short section of tunnel now connects three regional lines that have very different power and signalling systems."

An array of sewers, tunnels and pipes, alongside varying geology across London has made Crossrail one of the most





02

“It is easier to work in a multinational environment if English is your first language”

Andrew Boagey, RCEA

- 01** Crossrail is one of the world's most advanced rail projects
- 02** The UK's Victorian infrastructure presents unique challenges
- 03** Ailie MacAdam, global rail sector lead at Bechtel

Extension, have all helped cement Britain's reputation as a leader in railway engineering. For British engineers, these projects have given them the opportunity to tackle challenges that would have taken years to experience elsewhere. Many trainees spend periods of working with the maintenance and renewals teams, walking the track with track inspectors and or spending time in the signal repair shop. “This kind of practical hands-on experience builds both a thorough understanding of railway engineering and also a pride in the work we do,” said MacAdam.

Demand for skills such as this has risen globally and many expect it to continue doing so. By 2050, 75 per cent of people across the world will live in cities, so urban rail networks will need to be built and upgraded to meet the anticipated sharp increase in demand. And opportunities are available in some of the world's most exciting places, who are planning to expand their network significantly in the coming years. With more companies than ever operating on a global platform, it has never been easier for engineers to transfer their skills abroad.

“Australia and the US in particular are starting to realise the benefits of urban rail and there is currently a ramp-up of projects in both of these regions,” said Fitzgerald. “We need

03



experienced staff to deliver these projects but we are currently experiencing a global shortage of skills right across the engineering spectrum, including transport planners, engineers and project managers... Rail skills are not limited to a particular country: the UK has an extensive programme of investment mapped out that will give you the requisite skills that would then give you the chance to go and work abroad.”

MacAdam highlights new metro and urban renewals projects in Melbourne and Sydney, as well as in Toronto, Ontario and Edmonton, Canada. In Hong Kong, Singapore and Malaysia, there are rail projects focusing on high-speed rail, metros and urban renewals. “Bechtel is currently working in Saudi Arabia on the Riyadh Metro project where we have opportunities for railway engineers in systems assurance, slab track installation, tunnel ventilation systems, station construction and fit-out,” she said.

Meanwhile, Balfour Beatty has just been awarded a contract to undertake the electrification of Caltrain's 52-mile rail corridor between San Francisco and San Jose. “We've developed clever technology to tackle the challenge of ageing infrastructure, such as geometry measurement systems for track and overhead line structures and condition monitoring technology, and we're selling that expertise and innovative technology to customers across the world. Our engineers are accustomed to these leading-edge technologies,” said Mark Bullock, managing director of Balfour Beatty's UK rail business.

Philippa Oldham, head of transport and manufacturing at the IMechE, advises engineers considering a career abroad to first get experience at basic level in the demanding mixed-traffic UK environment. “This experience can then be taken abroad into either the project organisations inside major manufacturers, or into one of the major consultancies within global reach,” she said.

“There are always benefits to working overseas as it is a two-way learning experience. You can help train others in the techniques we have perfected in the UK and, at the same time, learn new skills as we certainly do not know it all,” added MacAdam. She believes engineers in the UK should take the leap if given the chance to work abroad.

“Do not over analyse, just do it. It's a big world with a lot to offer to those who want to learn and develop.” ☺

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1945

Jetting ahead

Sir Frank Whittle, inventor of the jet propulsion gas turbine, presents his ideas to *The Engineer*

By the age of 21 Sir Frank Whittle had conceived a technology that would transform military and civil aviation in a way that has remained largely unchallenged for 75 years.

It should go without saying that Sir Frank invented the jet propulsion gas turbine, and, in doing so, created a market that between 2014–2023 alone will require 55,000 new engines.

Some of those engines will be on the Airbus A350-1000, an aircraft coming into service next year with power being delivered by two Rolls-Royce Trent engines that will each deliver 97,000lb of thrust.

By contrast, Sir Frank's first jet propulsion gas turbine – the W1 – delivered 1,240lb of thrust, rising to 1,600lb with the development of the W2.

A remarkable element of the jet engine's story is the fact that Sir Frank was rejected twice by the RAF; an organisation that would ultimately reward him with a commission and an education.

No less remarkable was the fact that just a few months after the end of the Second World War, Air Commodore Frank Whittle, CBE, RAF, MA, Hon. MI Mech E had set about contributing a series of articles to *The Engineer* that would candidly and eloquently explain how the jet engine came into being.

"I first started thinking about this general subject in 1928, in my fourth term as a flight cadet at the RAF College, Cranwell," he wrote. "Each term we had to write a science thesis, and in my fourth term I chose for my subject the future development of aircraft. Among other things, I discussed the possibilities of jet propulsion and of gas turbines; but it was not until 18 months later, when on an instructors' course at the Central Flying School, Wittering, that I conceived the idea of using a gas turbine for jet propulsion. I applied for my first patent in January 1930."

The idea was submitted to the now defunct Air Ministry but turned down due to perceived difficulties surrounding a gas turbine. Similarly, Sir Frank tried and failed to

attract funding from a number of sources.

"I gave up hope of ever getting the idea to the practical stage, but continued to do paperwork at intervals, until, in May 1935, when I was at Cambridge as an engineer officer taking the Tripos course, I was approached by two ex-RAF officers (Mr RD Williams and Mr JCB Tinling), who suggested that they should try to get something started," he said. "Although I had allowed the original patent to lapse through failure to pay the renewal fee, and although I regarded them as extremely optimistic, I agreed to co-operate. I thought that there was just a bare chance that something might come of it."

With Messrs Williams and Tinling on board, Sir Frank was able to come to an arrangement with investment bankers OT Falk and Partners, leading to the formation of Power Jets in 1936.

The engine itself was to be a simple jet propulsion gas turbine having a single-stage centrifugal compressor with bilateral intakes, driven by a directly coupled single-stage turbine. Combustion was to take place in a single chamber through which the working fluid passed from the compressor to the turbine.

"I gave up hope of ever getting the idea to the practical stage but continued to do the paperwork at intervals"

Sir Frank Whittle

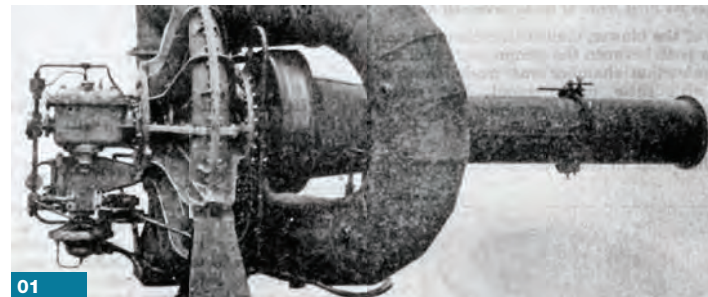
"We were going beyond all previous engineering experience in each of the major organs," he said. "We were aiming at a pressure ratio of about 4/1 in a single-stage centrifugal blower when at the time, so far as we knew, a ratio of 2t/1 had not been exceeded. We were aiming at a breathing capacity in proportion to size substantially greater than had previously been attempted.

"The combustion intensity we aimed to achieve was far beyond anything previously attempted. Finally, we had to get over 3,000 SHP out of a single-stage turbine wheel of about 16in outside diameter, and to do it with high efficiency."

The engine was tested for the first time on 12 April 1937, with the initial start-up declared a success.

"But it [the engine] accelerated out of control up to about half its designed full speed," wrote Sir Frank. "This happened several times, and altogether it was a very alarming business, so much so that in the early days the individuals in the vicinity did more running than the engine."

Just shy of his 34th birthday, Sir Frank saw his invention provide power for the new Gloster E.28/39 on its maiden flight from RAF Cranwell in 1941. **JF** ©



01



02

01 Close-up view of the jet engine designed by Sir Frank Whittle

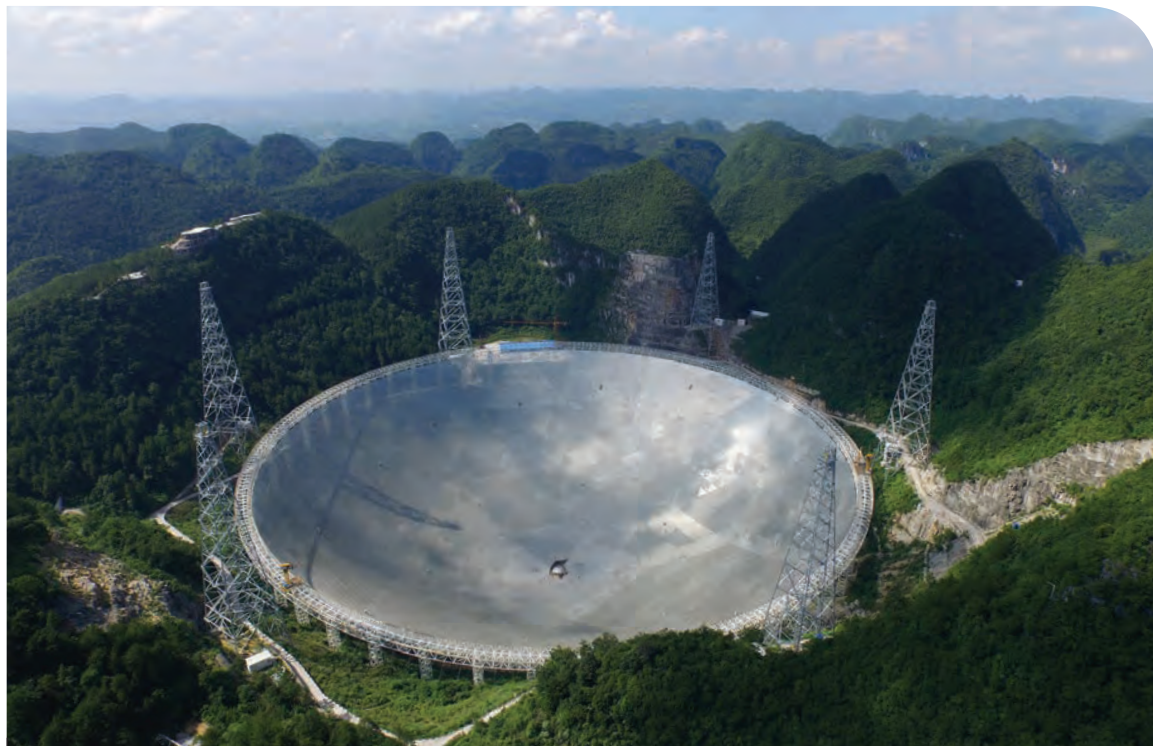
02 The Gloster E.28/39 aircraft before its maiden flight

Word of the issue

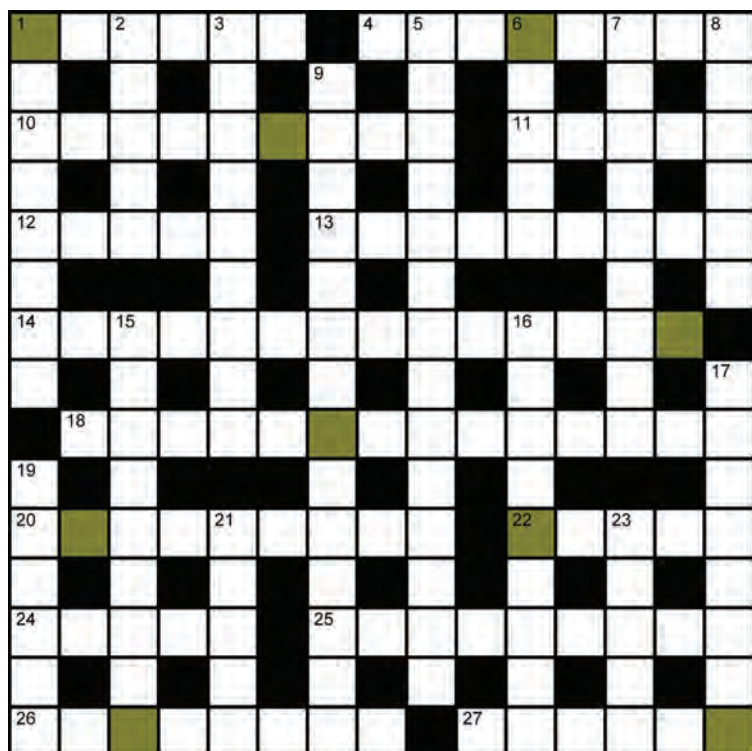
Anthony Poulton-Smith explores the origins of the word 'chamfer'

That minor but all-important touch making all the difference when it comes to the lead-in on a fastening. Even today it is easy to hear the French pronunciation and it came to English from across the English Channel. Its earliest use, in the 17th century, referred to a small groove in wood or stone; not until 1840 do we find the modern usage as a synonym for 'bevelled'. Taking the trail further back we find this came from the Latin *frangere* meaning 'to break' and from the full term *cantum frangere* meaning 'to break the edge'. While rarely heard outside the world of engineering, the Latin *frangere* has given us the term 'fraction'. Here the use of 'breaking' is probably easier to see, particularly as it began in a mathematical sense. Similar forms can be found in many languages. Indeed we can trace the meaning of 'to break' as far back as the Proto-Indo-European bhreg several thousand years ago.

Bigpicture



The world's biggest and most powerful radio telescope has been switched on for the first time, following five years of construction in southwestern China's Guizhou Province. The 500-metre aperture spherical telescope contains 4,450 reflecting panels across its half-kilometre aperture, and has a combined total area equivalent to 30 football pitches.



Prizecrossword

When completed rearrange the highlighted squares to spell out an excited state of a stable particle. The first correct answer received will win a £20 Amazon voucher. Email your answer to jon.excell@centaur.co.uk

Across

- 1 Launch an attack on (6)
- 4 Conduit through which liquid flows (8)
- 10 A worker skilled in applying render (9)
- 11 Spin around (5)
- 12 The lowest point (5)
- 13 A thermosetting resin used chiefly in strong adhesives (5,4)
- 14 The trade of planning the layout inside a building (8,6)
- 18 List advertising bits for machinery along with prices (5,9)
- 20 Case for carrying drawings (9)
- 22 Undergo a chemical change (5)
- 24 Twist into a state of deformity (5)
- 25 Making an opening or gap in (9)
- 26 People who make a will (8)
- 27 Scattered (6)

Down

- 1 Extra book material (8)
- 2 Burn with hot liquid (5)
- 3 Explain the meaning of (9)
- 5 System that keeps an area cool and dry (3,11)
- 6 Passage between houses (5)
- 7 Large, rotating machine with seats for children to ride on (9)
- 8 Uttered a sudden loud cry (6)
- 9 Impossible to patch up (14)
- 15 Short pauses from work (3,6)
- 16 Reduction in money paid to a worker (6,3)
- 17 Huge HQ of US armed forces (8)
- 19 Regulator for controlling the flow of a liquid (6)
- 21 A boy or man (5)
- 23 Dwell (5)

Last issue's highlighted solution was momentum. Winner: **Austin Brauser**

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