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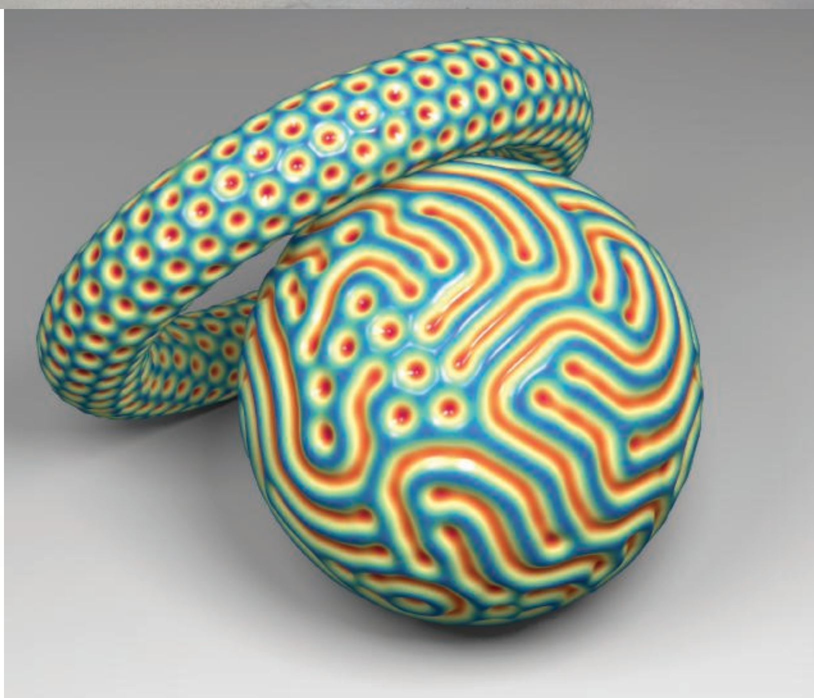
www.materialsforengineering.co.uk

Engineering Materials

Fuel cell car answers the composite volume conundrum

Metals exploit 3D printing



Unlocking morphing surfaces

ENHANCING TECHNOLOGY

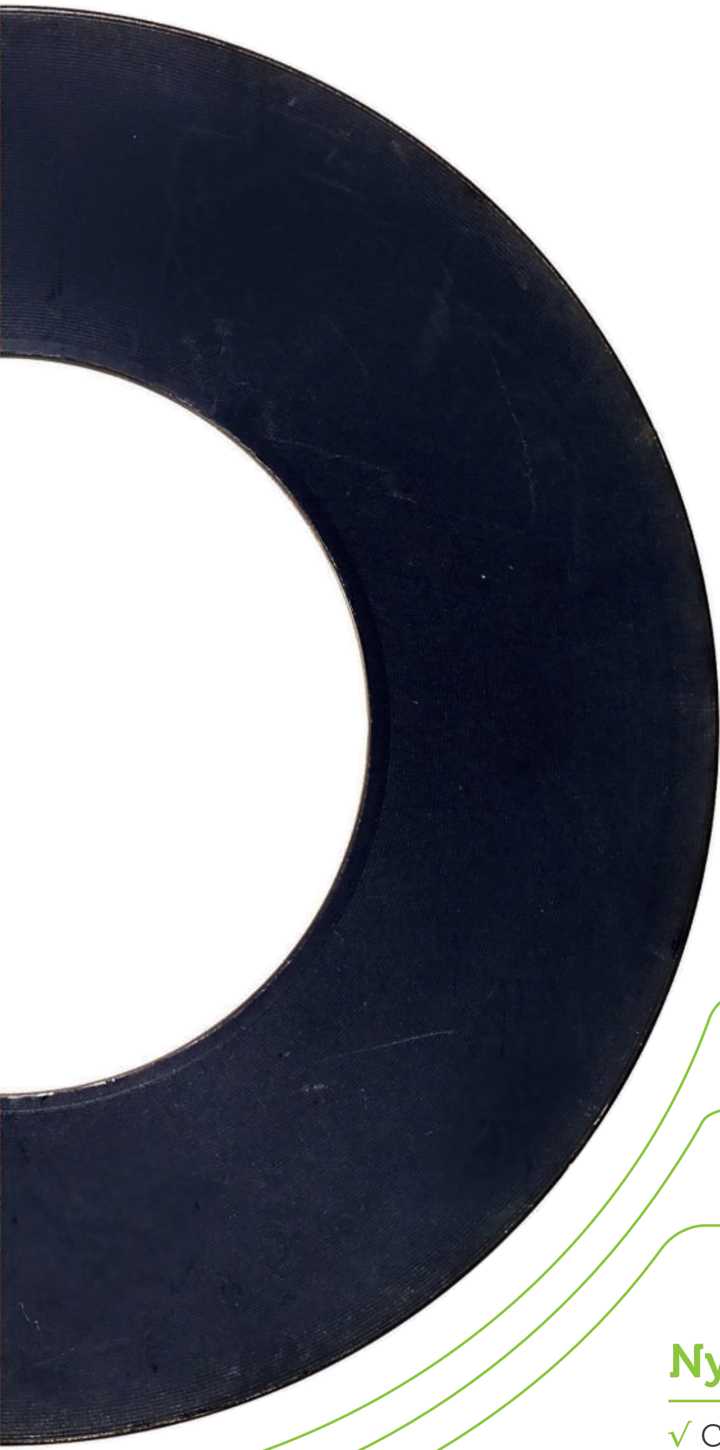
Through Engineering Design, Product & Materials Development

Metal

√ Dimensional stability
√ High strength
√ Conducting

× Oxidisation
× Corrosion
× High friction
× Conducting
× Poor sound dampening
× Maintenance
× Heavyweight

Image: two components manufactured from Steel and Nylacast Nylube, created to the same dimensions and requirements, both challenged through identical conditions and times.



POLYMER

Low Friction

Corrosion Resistant

Lightweight

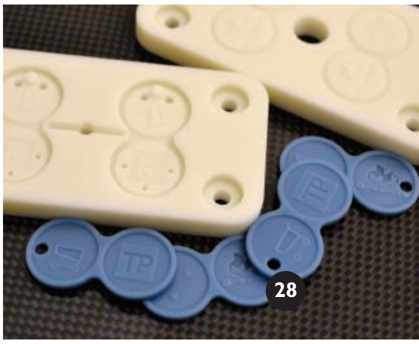
Nylacast Polymers

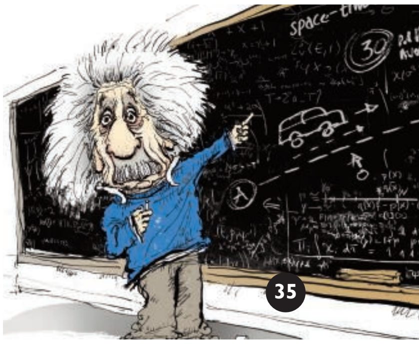
√ Cost effective
√ Low friction
√ Noise dampening
√ Chemical resistance
√ Corrosion resistance
√ High strength
√ Impact resistance
√ Insulation
√ Lightweight

× High temperatures (+180°c)
× Extremely high loads
× Insulating

*All statements and points are generically speaking, specific performance and values are dependent on the application, material grade, use, operating environment and conditions.

Contents





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Long time coming...

Justin Cunningham
Editor

I remember talking to spacecraft engineers about composite materials over 15 years ago, and how the commercial aircraft industry would struggle to ever capitalise on the materials advantageous properties. And they did struggle, but it is hard to now ever imagine Boeing or Airbus ever going back to that low-tech heavy shiny stuff from yesteryear.

And we've been having the same conversations about composites in the automotive industry since. But, I think, 2015 marks the year that the material goes in to serious high volume production. One thing is for sure though, no one agrees on the 'how'.

Some, like BMW, have been investing heavily in thermoset carbon fibre, while others are keen to develop something quite different – and that is thermoplastic carbon fibre composites. The obvious difficulty here is viscosity. Liquid Nylon, Acrylic or any of the forerunning engineering plastics are surely never going to properly wet out a spread-tow weave? I'm yet to be convinced and see it with my own eyes, but I'm told that actually it is quite possible.

At a press conference last year, Dupont executives told me that they had figured it out. But they didn't exactly shout about it. When asked 'how?', the response was a cheeky smile and simply, 'well, that is the difficult part.' They would not elaborate. At all.

And now, Toyota is saying similar things. We have an article on page 18 of this issue looking at the developments and it's interesting to note that while the car giant is giving away 5,000 patents on its fuel cell technology, it will not even comment on its thermoplastic composite developments. Something tells me that like Dupont, it thinks this is going to be huge, and it is something that the global car industry is going to want.

Now, no one knows if it is a conventional prepreg type process, if it will be laid-up in a regular manner or whether it will be longer discontinuous random fibres sprayed on – though I'd be a bit disappointed if it was the latter.

Whatever the details are, it does appear that this is the year we will see composite vehicles rolling off various OEM production lines in what will be initial runs of 'mass-produced' composite cars. These are not concept cars, they are not marketing gimmicks (well... ok maybe a bit), they are the culmination of years of development. And I'm sure it won't be long before lightweight composite chassis become the norm.

@TheEngineer Hack

Materials Update

Mercedes to use polyamide crossbeam

Fibreglass reinforced polyamide has been used in the construction of the transmission crossbeam – part of the rear axle – on the new Mercedes-Benz S-Class. The component, created using BASF Ultramid, is said to offer optimum strength, good noise, vibration and harshness performance, as well as high crash protection. As a central component of the rear axle, it is about 25% lighter than die-cast aluminium versions.

"The rear axle transmission crossbeam is a milestone in the use of polyamides on the chassis and has the potential to set a new trend in the automotive industry," said Kai Frühauf, head of the Vibration Control business unit at ContiTech - a specialist in rubber and plastics technology that helped with development.

Polyamide components allow vehicle designers to reduce weight. And, unlike aluminium, polyamide can be shaped at lower temperatures.

"Absolute precision is called for in the design and production of the transmission crossbeam – particularly in terms of the strength and dimensional accuracy of the component," said Diethard Schneider, head of lightweight construction predevelopment at ContiTech. "Only when all the properties are exactly right can the component be assembled in the axle system without any problems. The fact that premium suppliers are among the forerunners shows the trust and confidence engineers have in polyamide components for engine and chassis applications."

www.basf.com
www.contitech.de

US to develop composite market

New Jersey based Evonik has recently been named a key partner of the Institute for Advanced Composites Manufacturing Innovation (IACMI), the US backed $250 million public-private partnership of academia, government and industry. It seeks to advance the commercialisation of novel material sciences and composite solutions to the automotive, wind energy and compressed natural gas tank sectors.

Evonik already manufacture a range of products and the company supplies core materials for sandwich construction, thermoplastic and thermosetting resin matrices, as well as the essential components for matrices such as crosslinkers, catalysts, impact strength modifiers or processing additives.

Dr. Matthias Kottenhahn, head of Evonik High Performance Polymers business line, said: "We have a strategy of offering the world commercially viable ideas on how to utilise resources more efficiently... And to develop new materials and innovative light-weighting system solutions."

www.evonik.com/composites

Rubber modified epoxy to prevent thermal stresses

The adhere IRS 2129 rubber modified adhesive from Intertronics is a black rubber modified resin system, designed to bond dissimilar materials, with differing rates of thermal expansion.

It can be used for different substrates, including rubber, found in applications such as electronics, electrical and other specialist component assemblies, for example in automotive and specialist vehicle manufacture.

The uncured flow has been adjusted to prevent 'slump' during application. It cures to a semi-rigid state of Shore A90 hardness, to help prevent stresses in components and the bonding of materials in dynamic environments.

The two-part epoxy system has a simple 1:2 mixing ratio, and is supplied in a side-by-side syringe cartridge, with static mixing nozzles.

It is non-toxic and thixotropic with adhesion suitable for metals, rubbers, GRP, wood, glass, ABS, PVC, PC and PMMA.

www.intertronics.co.uk

Metal adhesive set for hotter motors

Industrial adhesives developer DELO has developed a metal adhesive for electric motors that is said to combine a broad temperature range with fast and simple production processes.

The DELO-ML DB154 adhesive is a light curing methacrylate, designed mainly for bonding tasks in electric motors, including bonding of buried magnets, rotor packages and shafts to hubs. It is suitable for use in temperatures of up to 180°C and is said to have a shear strength twice that of other methacrylates at the same temperature. The adhesive is also said to retain its strength, even with frequent contact with gear oil, motor oil and gasoline.

Cured by exposure to UV or visible light, initial strength is achieved within 6s, with the dual curing adhesive achieving full strength under exclusion of oxygen.

The medium viscous adhesive adheres to steel and aluminium, as well as to rare earth magnets. If an activator is used, metals can also be joined to a component made of plastic.

www.delo.de/en

Superfinishing gears adds power to superbikes

PDJ Vibro has partnered with Nova Racing – one of the only companies to supply racing gearboxes to the British superbike grid – to polish the gears and shafts in a process referred to as superfinishing.

There are very few gears, shafts and selector parts that are not superfinished at the Nova factory as it has now installed its own vibratory finishing bowls.

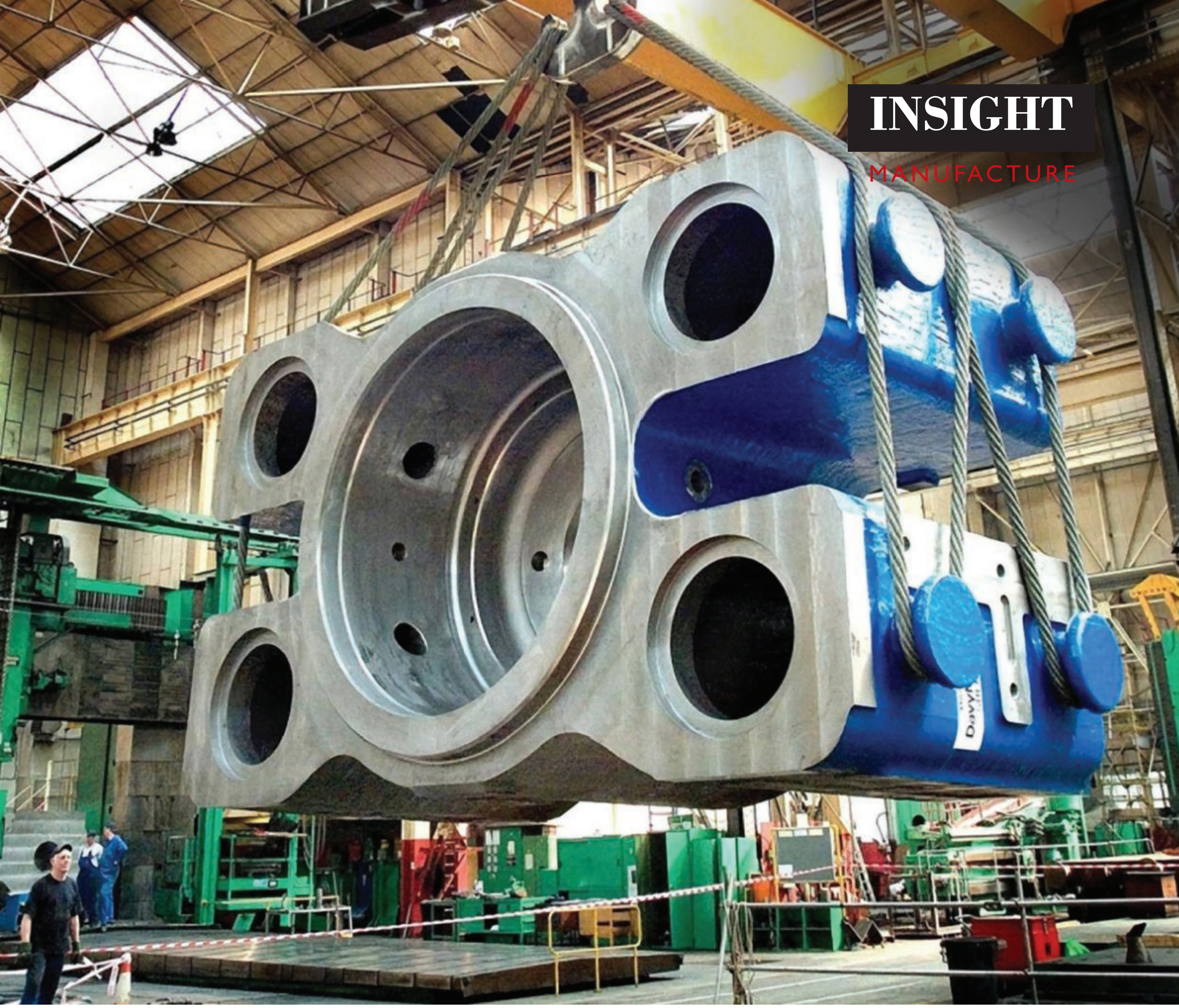
Nova director, Sean Whittaker said: "There is no doubt that the gearboxes last longer, as the period between our supplying a gearbox and getting it back for refurbishment has been extended. It is because there is less wear on the gear teeth and reduced friction between the bearings."

A further benefit of having polished moving gearbox parts is that the time needed for running-in is shorter.

The process also gives a highly polished surface finish to the gears that can take on different colours, ranging from light brown to green-grey, after machining, hardening and oil quenching.

A batch of parts is processed for five hours in one of the 100 litre capacity bowls, which are filled with two sizes of ceramic medium to optimise finishing over the entire surface of the components. A recirculating water and detergent mixture prevents oxidation of the steel. The components are then transferred to a second bowl containing smaller porcelain stones to be polished in a water and detergent mixture.

www.novaracing.co.uk
www.vibratoryfinishing.co.uk



World's biggest casting

Whoever said, 'Britain doesn't make anything anymore', obviously isn't from Sheffield. In fact the city is producing some of the largest castings ever produced for German company SMS Meer.

Sheffield Forgemasters International (SFIL) won the landmark $19 million contract to deliver 11 castings over the next two years that weigh in excess of 320 tonnes each, making them some of the largest individual cast components ever manufactured anywhere in the world.

Manufacture of the giant components has now begun and it will see the production of more than 6,000 tonnes of molten steel, with each casting requiring multiple ladles of steel poured continuously.

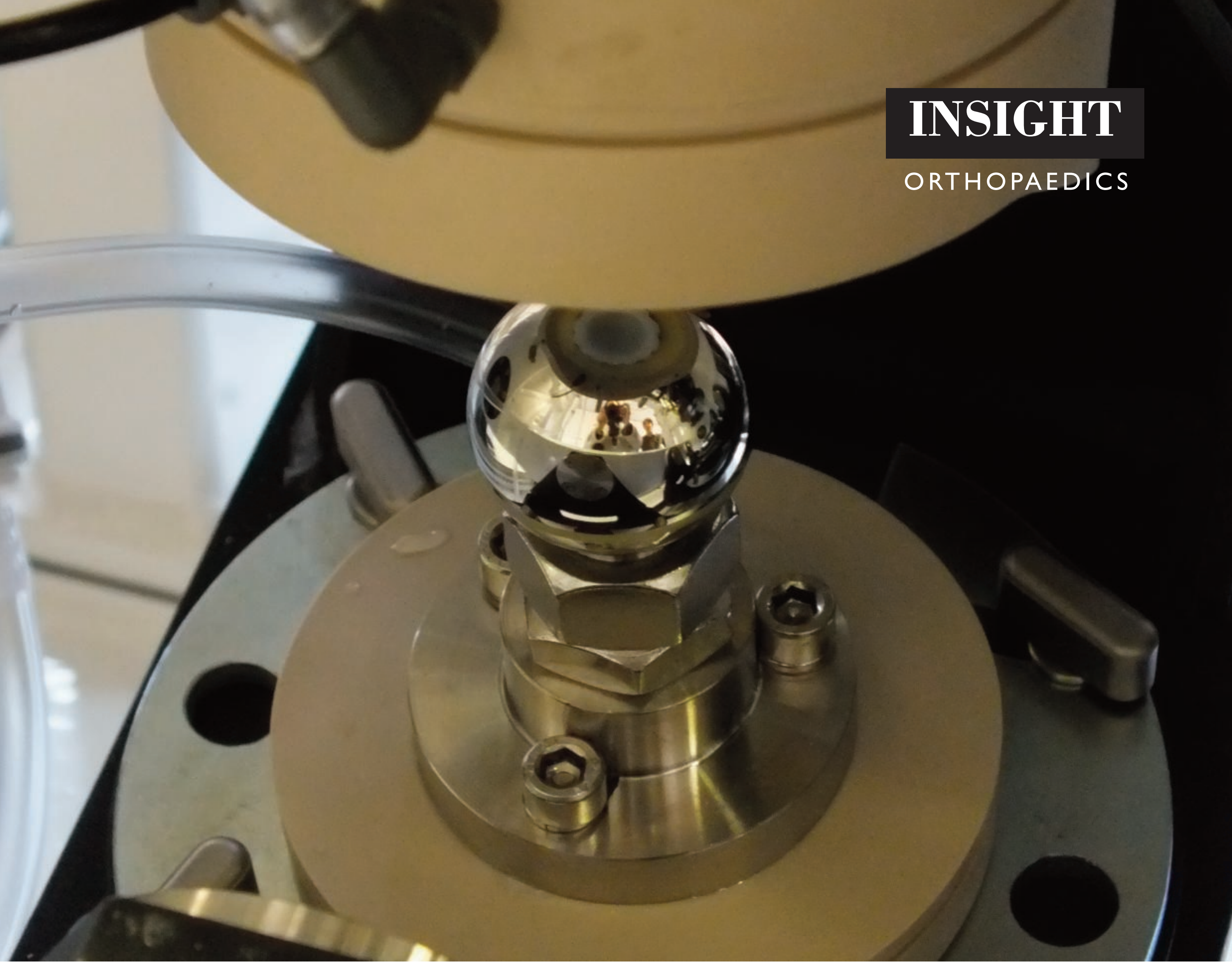
Dr Steve Price, managing director of sales at the company said: "This contract is important for Sheffield Forgemasters and for the volume of work it brings to the city. It is also important for the UK, as one of the few countries in the world, and the only country in Europe, with the skills and capacity to produce these ultra-large castings."

The company boasts the largest foundry facilities in Europe and is one of very few in the world able to manufacture such large cast components.

Sheffield Forgemasters has a track record of casting 'firsts' including the largest ever cast nodes for use offshore, created for the Aasta Hansteen Spar platform in 2013.

SFIL has previously worked with SMS Meer, a world leader in the production of metals processing and manufacturing machinery to produce a broad range of technically challenging, ultra-large castings.

www.sheffieldforgemasters.com



'Bio-tribology' tests defined

The orthopaedic implant sector is in a continual state of development, witnessing an explosion in novel materials' application and radical design alterations. This process is, however, often laced with challenges and articulating joints present a great number of these.

It has led to Stoke based materials development, testing and assurance consultancy Lucideon to release a Whitepaper highlighting the key techniques for testing the materials and associated design of implants, along with defining 'bio-tribological' test regimes. Bio-tribology is the study of friction, lubrication and wear of mechanical components in the human body and the factors to consider in the design of implants. Assessment of an implant covers three areas - mechanical testing, debris analysis and surface analysis.

The aim is to focus on generating an understanding of the orthopaedic implant in terms of how the design, base material or coating copes with the day-to-day movement of the body.

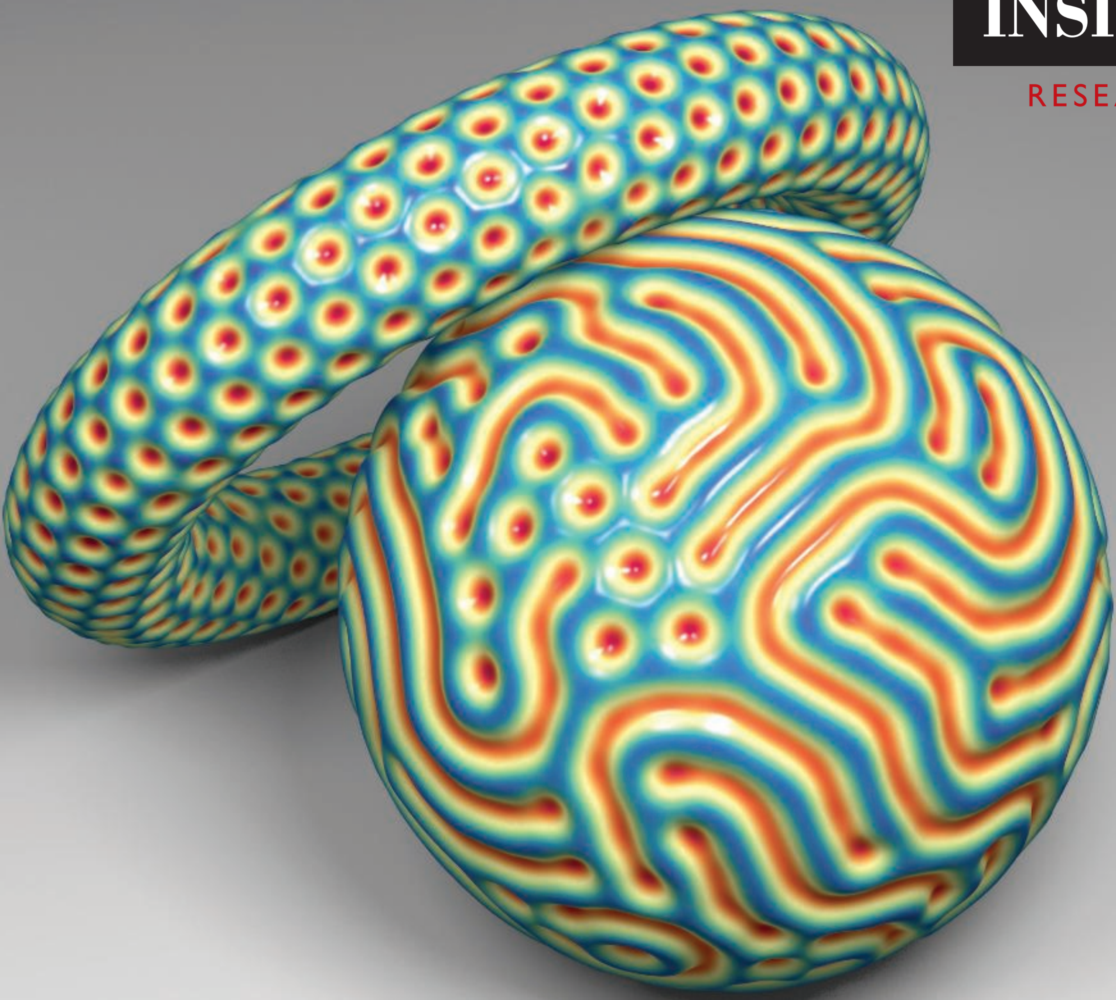
Like any mechanical system with moving parts, the implant suffers tribological effects including applied stresses and frictional forces, particularly those with articulating surfaces.

Issues associated with wear of an implant can be severe and range from heat generated due to friction to particles coming off the device and causing adverse effects to the surrounding tissue. Worse still, delamination of a coating following cracking can be catastrophic and completely debilitating for a patient.

Properties like improved wear and corrosion resistance will improve the longevity and behaviour of implanted devices, and any stresses associated with an implant depend on the patient's body weight and physical activity, which should both be factored into the process of designing any implant.

Indeed, the testing process must also be all-encompassing and physiologically relevant to generate valid findings.

www.lucideon.com



Wrinkles prediction prelude to morphing materials?

A team from the Massachusetts Institute of Technology (MIT) in the US have developed a theory that predicts how wrinkles on curved surfaces occur and take shape.

Jörn Dunkel, an assistant professor of mathematics at MIT, said: "It's a complicated system, but there seems to be something generic going on because you see very similar patterns over a range of scales."

According to Dunkel, there exists a mathematical framework for describing wrinkling in the form of elasticity theory, a complex set of equations to predict the resulting shapes in computer simulations. While these equations are far too complicated to pinpoint exactly when certain patterns start to morph, (let alone what causes such morphing) by combining ideas from fluid mechanics with elasticity theory, the team derived a simplified equation that can accurately predict wrinkling patterns.

Dunkel explained: "What type of stretching and bending is going on, and how the substrate underneath influences the pattern — all these different effects are combined in coefficients so you now have an analytically tractable equation that predicts how the patterns evolve, depending on the forces that act on that surface."

Curvature is one major determinant. The more curved an object, the more regular its wrinkled surface. The thickness of an object's shell also plays a role. If the outer layer is very thin compared to its curvature, an object's surface will likely be convoluted, similar to a fingerprint. If the shell is a bit thicker, the surface will form a more hexagonal pattern.

The group's theory, although primarily based on work with spheres, may also apply to more complex objects and the theory could serve as a design tool to engineer objects with morphable surfaces.

www.mit.edu

SHOW TIME

As Europe's biggest composites show approaches, we look at the innovations that have been making the headlines. *Justin Cunningham* reports.

The demand for lightweight strong materials continues at pace, with numerous composite applications coming to the fore in the last 12 months. These continue to impress, push boundaries and increase uptake.

As a result, this year's *JEC Europe Composites Show* will be packed with innovations from every industrial sector, from raw material producers to end-user markets, with the very best applications set to receive an *Innovation Award*. Here are some of the most promising and impressive to be on the show floors.

JEC Europe will occupy three levels at the Paris Expo Porte de Versailles and be held from Tuesday March 10 to Thursday March 12, 2015.
www.jeccomposites.com

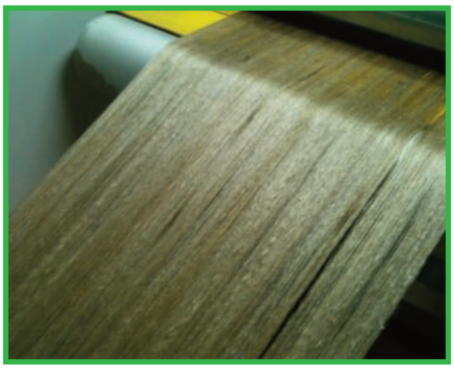
Long flax fibres in a thermoset reinforced sandwich panel

The Flaxpreg project, developed by Faurecia with PSA Peugeot Citroën, Lineo and the University of Reims, aims to design structural trim parts following three objectives: drastic weight reduction, the use of renewable resource, and cost and cycle times in line with automotive industry expectations.

Flaxpreg is a 'green' lightweight thermoset sandwich reinforced panel that uses very long flax fibres. It can be effectively used as a trunk load floor or even as a structural floor in the passenger compartment of a vehicle. The very low density of the FlaxTapes combined with their adaptive 0°/90°/0° orientation (for each skin) result in a 35% weight reduction compared to petroleum sourced glass mat/PUR sandwich solutions with the same mechanical properties.

The prepreg FlaxTapes (about 120 g/m²) that constitute the skins are unidirectionally-aligned flax fibre tapes and with acrylic resin are easily handled without any spinning or weaving steps. It means it avoids out-of-plane crimping of the near continuous flax fibres.

Flaxpreg aims to compete in markets dominated by Baypreg thermoset technology (PU + glass fibres).



MAN leads project to cut the weight of bus beam by 70% using CFRP

The air spring beam used on buses made by German based commercial vehicle manufacturer MAN have been redeveloped using Carbon Fibre Reinforced Polymers (CFRP), resulting in the component weight being slashed by 70%. The beams were previously manufactured in steel and weighed 53 kg, but the new composite components weigh just 16 kg.

MAN had the idea to manufacture the beam from CFRP to reduce weight and looked for a partner that could build the component and also produce it in high volumes. Munich Composites designed the prototype for the CFRP beam.

But it's the processing technology that's been really key. Where repeatability is a must for the automotive industry, the composite beams have to guarantee the highest part quality. It was this that saw them select and develop a braiding technology to produce the CFRP beam, as the process is completely automated.

Several robots guide the core of the beam through the braiding machine (above) without any manual interference whatsoever. It enables high productivity and very low scrap, as well as cost effective production parts.

Bolt on generic carbon fibre motorcycle wheel

The wheel produced by South African Blackstone Tek is able to reduce the amount of aluminium in the wheel assembly by 32%, allowing for a lighter and optimised structure. It was also able to optimise the production process by developing an out-of-autoclave curing process for the pre-impregnated material used to create the wheel. The process includes the oven curing of the wheel using a purpose-built, internal and external pressure device that can be removed and reused on subsequent wheels.

Carbon fibre motorcycle wheels offer benefits such as lower weight, lower rotational inertia, and high stiffness. These benefits allow for the motorcycle to achieve greater fuel efficiency, greater acceleration, better braking distances, as well as better cornering.

The nature of the components included in the wheel assembly also reduce the wheel's susceptibility to corrosion. These effects all contribute to the overall improved performance and safety of the motorcycle. In addition to these technical benefits, the aesthetics of the wheel is an undeniable benefit.

Carbon fibre frame design for automotive body could be game changer

At the core of the pioneering frame around the Hyundai Intrado concept car are carbon fibre reinforced polymer (CFRP) tubes, which are reported to be as flexible as rope. By aligning and then curing them, the resulting structure becomes rigid and strong, but incredibly lightweight by comparison.

The frame is formed from precisely shaped continuous loops made from the newly formed material. These serve as self contained modular frames for the roof, hood and even the doors on either side of the car, which are then bonded to each other along their lengths at ambient temperature.

The seals of the opening panels shut directly against these frames, further reducing weight and showcasing the carbon fibre whenever the doors, hood or trunk are opened.

By bonding the carbon loops along their lengths, rather than at cross-sections, the Intrado's frame is stronger and suffers from less torsional stress, meaning the agility and precision of the engineering remains constant. Additionally, the 'open' corners allow designers greater flexibility.

Running along the length of the Intrado is a floating centre console beam. This beam provides the Intrado with its unique strength in addition to connecting the passenger compartment and powertrain with the carbon frame.

By building the Intrado with advanced carbon fibre reinforced composites, a 50% saving in the overall weight is achieved compared to similar steel structures. In addition these unique qualities make it more repairable than typical carbon fibre structures.

3D permeability bench to aid composite proliferation

The main objective of EASYPERM is to enable the use of composite materials by increasing the level of understanding in end users. Permeability measurements help users to simulate processes, compare reinforcements and check reinforcement quality.

The EASYPERM bench is reported to be the only system on the market that offers an industrial solution for measuring the permeability of a dry reinforcement through thickness (Z) and in-plane (X, Y).

EASYPERM allows evaluation of the reinforcement once it has been impregnated by a liquid resin. This is a crucial step in performing filling simulations for large and complex parts, and also for process optimisation in the case of high production rates.

EASYPERM has been developed by French company PPE, which benefits from more than 10 years experience in permeability measurement and associated device development.

Pumping up the

Composites and the automotive industry are yet to answer the volume question. So will thermoplastics allow lightweight structures be produced in their millions quickly and at the right price? *James Bakewell* finds out.

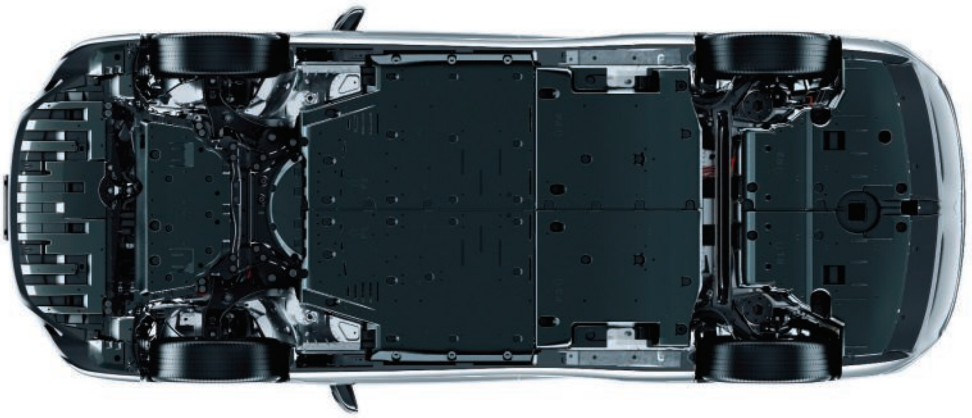
Toyota's Mirai could be a game changer. The four seat sedan is the first hydrogen fuel cell powered vehicle to be produced in commercial numbers. It can travel just short of 500km on a single tank of hydrogen, can be refuelled in less than five minutes and the most harmful compound emitted by its powerplant is water.

Less likely to grab the headlines – but of significant interest to automotive structural engineers – is the fact that the Mirai is claimed to be the first mass produced vehicle to feature a carbon fibre reinforced thermoplastic (CFRTP) structural component.

The chief executive officer of market research company Lucintel, Dr Sanjay Mazumdar, says: "This is a significant development for mass produced vehicles. It demonstrates that suitable processing technology can be developed for the consistent manufacture of CFRTP parts in high volumes. Such moves by original equipment manufacturers (OEMs) will accelerate the use of CFRTP in more vehicle platforms."

The CFRTP component is the undercover of the Mirai's fuel cell stack and forms part of the floor of the vehicle. It is interesting to note that while Toyota is happy to make over 5,000 of its patents relating to hydrogen fuel cells available on a royalty-free basis, it refuses to even discuss the technology behind the production of the CFRTP stack frame.

However, what is known is that the stack frame is fabricated using a press moulding process developed by Toyota and carbon fibre manufacturer Toray, which the two companies claim is suitable for high-volume production. Like all carbon fibre reinforced polymer (CFRP) parts, it will be light and strong.



The Toyota Mirai might grab headlines as the first mass produced fuel cell car, but it is the carbon fibre reinforced thermoplastic floor that will most likely be seen as a game changer in the near term

Furthermore, the two companies will have capitalised on the advantages that thermoplastics present over the thermoset matrices more commonly used in the automotive industry for the production of structural composite parts.

The need to lighten

Automotive OEMs are working hard to reduce the weight of their vehicles in the face of strict regulations on fuel economy and carbon dioxide emissions. For the production of lightweight structural components, they are increasingly looking to CFRPs. According to chemical giant BASF, the market for composites in automotive body and chassis applications will be worth €2 billion by 2025.

However, thermoset based CFRPs are expensive and the processes used to convert them into production ready components have traditionally been too slow for use in high-volume manufacture. Carmakers and composites producers are now looking to develop materials and processes that would solve these short comings.

First, existing production processes are being optimised, as is the case with the resin transfer moulding (RTM) process employed by BMW to fabricate the chassis of its i3 and i8 – currently the only mass-market vehicle to feature the extensive use

volume

Toyota want the fuel cell powered Mirai to have the same success as the Prius has had in developing the hybrid-electric car market

Composite materials have been a key enabler for the Toyota Mirai

of CFRP. Second, new material systems are being introduced, such as epoxies with drastically reduced curing times.

Despite these advances, the epoxy used by BMW still takes five minutes to cure at 100°C, and 10 minutes to de-mould – a long time for carmakers more used to being able stamp a metal component in a matter of seconds.

The road to commercialisation

Japanese chemical and pharmaceutical company Teijin and its partner General Motors are working on materials and processes that could enable the press-forming of continuous-fibre reinforced thermoplastic components in cycle times of under a minute.

Known simply as Sereebo, the materials technology has been blanketed in secrecy since its announcement in March 2011. Under development at the Teijin Composites Application Center (TCAC) in the USA, the Sereebo range comprises three intermediate materials.

The first, called U Series, is a unidirectional material offering high directional strength. The second, I Series, is isotropic offering a balance of shape, ease of moulding and multi-directional strength. The third, P Series, is a long carbon fibre reinforced thermoplastic (LFT) pellet, and is suitable for the injection moulding of components.

Dr Nick Weatherby, technical director of independent polymer composite specialist EPL Composite Solutions, says: "Thermoplastics possess a combination of recyclability, and can exhibit unique properties with regard to impact and resisting strain [fatigue]. They really are the future."

In contrast to thermosets, whose cure reaction cannot be reversed, thermoplastics harden when cooled yet retain their plasticity. It means they will remelt and can be reshaped by heating above their original processing temperature, and so can be more easily reused and recycled, unlike thermosets.

Furthermore, once melted thermoplastics harden quickly at relatively low temperatures, meaning that reinforced thermoplastic parts could be produced rapidly in short cycle times – especially using compression moulding processes.

In partnership with Cytec, EPL is working on UK-ECOPROCESS, a Composites Innovation Cluster project funded by the UK Government's Advanced Manufacturing Supply Chain Initiative (AMSCI), to develop methods for the production of low-cost, near-net shaped thermoplastic prepregs – reinforced with glass, carbon or aramid fibres – and suitable for a wide variety of recyclable components such as roofs, bonnets, boot lids and wheel arches.

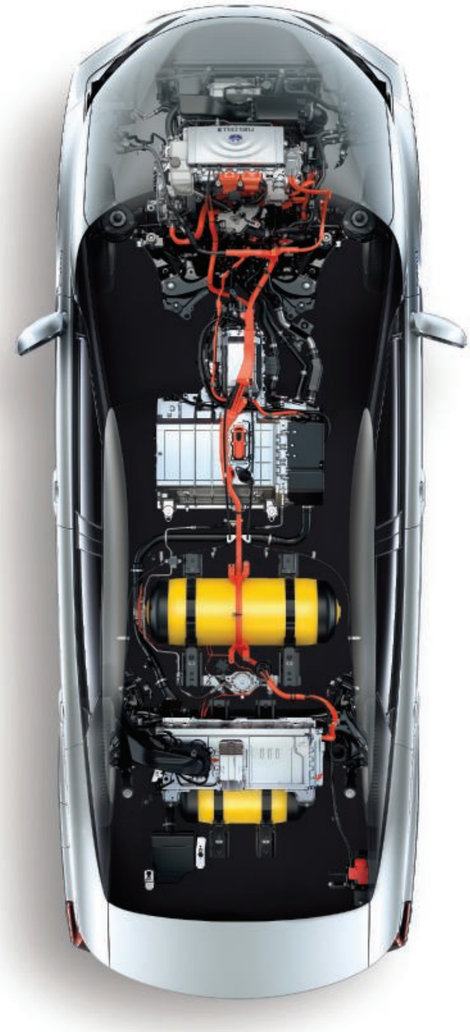
Defying convention

Using conventional methods for the production of thermoplastic prepregs, thermoplastic fibres are woven with reinforcing fibres to create a fabric or tape. The methods being developed through UK-ECOPROCESS avoid the need for this step, reducing cost.

The base materials employed in the process are chopped rovings made from a thermoplastic and the chosen reinforcement.

Dr Weatherby says: "We send the rovings, which can be intermingled, co-mingled, co-extruded or a mixture of separate rovings, straight through a very specialised chopper system and then we use a robot to spray them onto a tool in an oriented way."

The resulting preform is then subjected to heat and pressure in a high-speed press to produce a part. The properties of the component can be optimised by adjusting the chopped length and orientation of the fibres.



Toyota has made 5,000 of its patents relating to hydrogen fuel cells (left) available on a royalty-free basis, yet it refuses to discuss the technology behind its thermoplastic composite components. A demonstrator part manufactured using BASF's Ultracom package (below)

According to Dr Weatherby: "This allows us to tune the materials as if they were woven, but of course, they are not."

The project partners are able lay down up to 2.5kg of chopped material a minute, and their hybrid chopper is able to process around 100 tonnes of glass based rovings without the need for maintenance — a significant improvement over conventional breaker or shearer choppers. This means that the process is capable of producing large amounts of thermoplastic composites in a cost-effective manner.

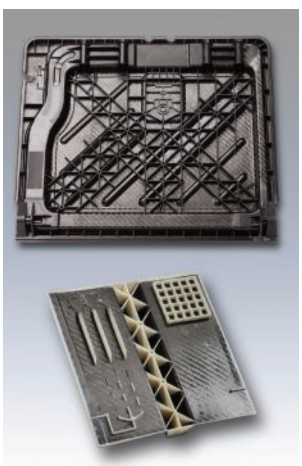
The disadvantage?

Of course, thermoplastics do have their drawbacks, such as high viscosity – which can limit volume fraction – and high melt temperatures; typically between 180 and 250°C.

These high melt temperatures make the capital equipment needed to process thermoplastics expensive, although as Dr Weatherby points out: "This is less of an issue for automotive and industrial OEMs because they tend not to concern themselves too much with the cost of capital equipment. It's more about the volume part price."

However, the high viscosity of many thermoplastics prevents them from wetting out fibre preforms in a consistent fashion, precluding them from use in the RTM processes favoured by many OEMs for the production of structural parts.

As a result, Volkswagen (VW), KraussMaffei and BASF have developed a low-viscosity reactive system for use with a thermoplastic resin transfer moulding (T-RTM) process.



To demonstrate the process, the partners have produced a continuous fibre reinforced polyamide (PA) B-pillar reinforcement, a part currently made by VW using high-strength steel. The composite component is 36% lighter than its metal counterpart.

The reactive system comprises a caprolactam, an activator or a catalyst, and additional additives supplied by BASF in the form of two ready mixed components. Above 70°C, the caprolactam melts and possesses a water-like viscosity, lower than that of many epoxies. This enables the monomer to efficiently wet the reinforcement at an injection temperature of around 100°C. The system then polymerises to a PA6 in an isothermically heated mould in approximately three minutes.

The injection and curing of the demonstrator B-pillar reinforcement took less than five minutes, and the project partners are confident they can reduce this time further.

Furthermore, BASF has launched a package of materials and services that it claims would enable the mass production of reinforced structural and semi-structural thermoplastic components. Called Ultracom, the package comprises of continuous fibre reinforced semi-finished products, specially adapted compounds for over-moulding products and complementing engineering support.

The semi-finished products – laminates based on woven fabrics and unidirectional (UD) tapes impregnated with Ultramid PA or Ultradur polybutylene terephthalate (PBT) – have been developed in partnership with TenCate Advanced Composites and Owens Corning.

The overmoulding materials – based on Ultramid and Ultradur compounds – have been developed specifically for use with these laminates. By using them in combination with the laminates and tapes, it is possible to mould complicated parts that are highly reinforced in precisely defined locations while incorporating other structures on their surfaces, such as ribs.

The company is currently developing applications for its T-RTM process and is working with a variety of partners. The company is also working with carbon fibre manufacturer SGL to develop thermoplastic compatible coatings for carbon fibres that increase the strength of the bond between the fibre and the resin.

Much like hydrogen fuel cell powerplants, the increasing use of thermoplastics could have a profound effect on the automotive industry. But, it remains to be seen exactly how the two technologies will evolve. Time will tell.

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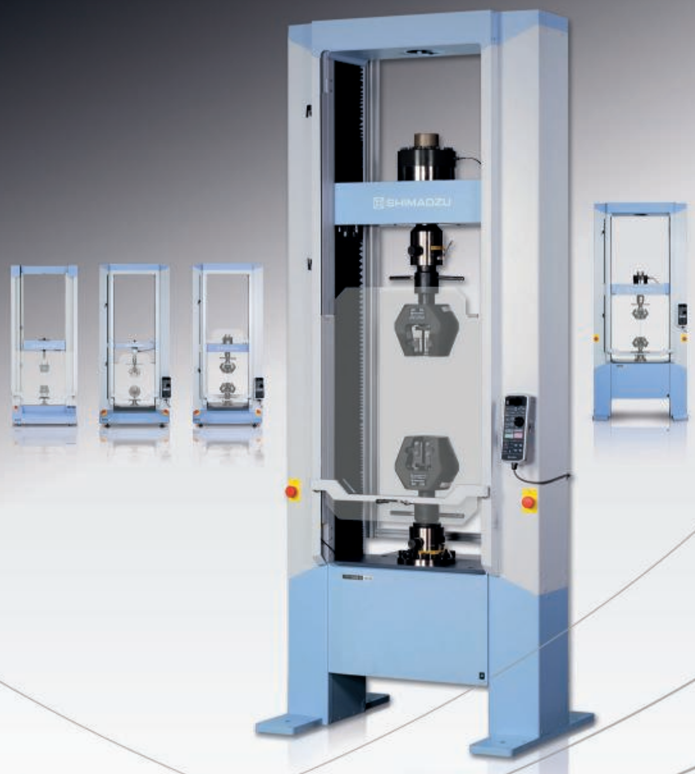

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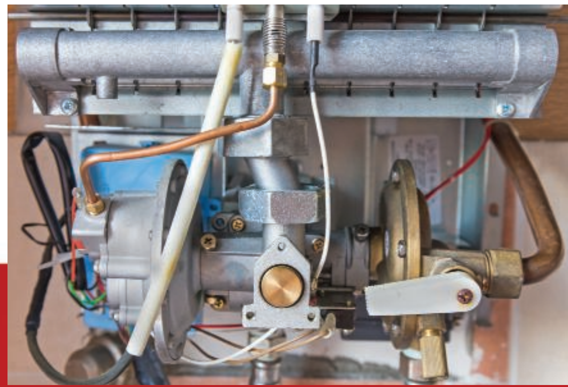

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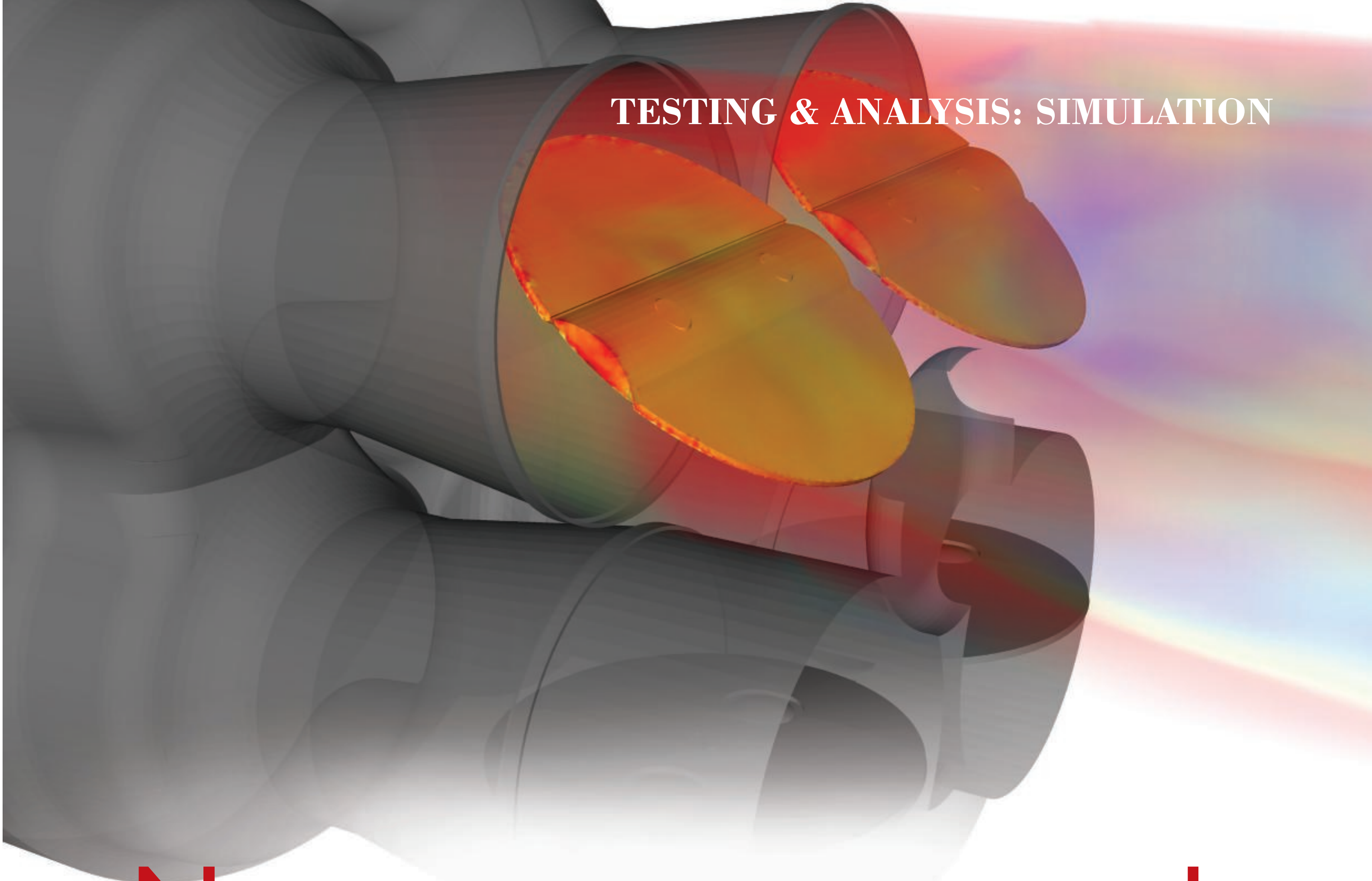


No **more messy** mesh

Despite being used by many engineers, CFD is far from straightforward. So when someone claims to have made the process easier, it is understandably met with scepticism.

Computational fluid dynamics (CFD) has been a valued development tool for engineers in selecting materials, understanding phase change, and honing geometry in fluid flow applications for many years. And one area where it has seen considerable success is in the development of internal combustion engines.

By analysing the different geometries and surface finishes of materials, cylinders and pipe work – research and development time has been slashed while considerable gains in performance have been found.

It was this reason that saw motorsport as an early CFD adopter. But despite the benefits, issues remain including long processing times, meshing difficulties and trust in the data.

Experienced engine developer Brian Kurn currently heads valvetrain development at US based high-performance engine producer, ECR Engines. As a practiced CFD user, primarily to analyse internal flows in the engine, Kurn is all too aware of the issues associated with CFD.

"In the past, the run-times to do the simulations took too long and when we had to create our own mesh, we really suffered with variability between users," he says. "It can affect your results, introduce inconsistency and ultimately your trust in the data can go out of the window."

As any seasoned user knowns, the quality of the mesh is crucial and while developers have tried to devise CFD programmes that would automatically generate it, a lack of accuracy meant users usually have to put up with the ensuing errors.

"I never believed that an effective automatic meshing tool would happen in my lifetime," says Kurn. "I thought we would be stuck with the longer run-times and other compromises."

However, US firm Convergent Science is laying claim to an automated meshing solution that does away with the errors. It says users supply a triangulated surface and a series of guidelines and Converge software creates a grid at run-time.

Convergent Science's marketing director Rob Kaczmarek, says: "Users struggle with hard-to-define areas and this leads them to go to a larger-sized mesh, maybe up to 1mm, in order to save time. Unfortunately accuracy suffers with this approach.

"Converge refines the mesh when and where it is needed at run-time, retaining accuracy, while keeping run times manageable."

Having heard such claims before, Kurn along with many other users were sceptical. But upon using it his view changed.

"We gained literally weeks on some developments in 2014," he says. "Knowing the exact parameters of key items such as combustion chamber, intake and exhaust ports meant when we make changes, we can accurately measure those and have complete control over them."

The membrane **marvel**

Smartphones are being used for evermore varied applications, so protecting the delicate components inside from the elements has become vital. *Engineering Materials* takes a look at how a membrane technology designed for clothing is now being used to ruggedise electronic devices.

Almost a billion smartphones were sold in 2014. As well as the ongoing trend of increasing sales, they are also being used in more extreme environments, from logging a run to filming skydives to taking underwater snaps, todays smartphones are expected to keep working regardless.

And it is not just extreme environments, most are exposed to rain at some point, many are dropped, have drinks spilled on them, or are taken to the beach. And a bizarre frequency are accidentally dropped down the toilet - reported to be as many as one in five!

One risk is that liquids and particulates can enter through a device's acoustic openings such as the microphone, receiver and speaker. In addition, if the acoustic transducers are compromised in some way, sound quality can be affected, ultimately leading to device failure.

Features such as high-resolution cameras, multiple acoustic transducers and electro-mechanical components such as enclosure gaskets and flex connectors have also made providing long-term smartphone reliability that much more complicated.

Indeed, typical causes of failure and poor performance include water and particulate ingress through ports and connectors, electrostatic discharge, liquid and particle ingress, and shock due to being dropped.

To this end, US based W. L. Gore & Associates – famous for its GORE-TEX textile material that is both breathable and waterproof – has teamed up with many electronic device OEMs to collaborate on innovative waterproofing solutions.

The company has developed vents that use expanded polytetrafluoroethylene (ePTFE) membranes. These use a node-and-fibril construction that permit gas molecules (air) to pass through while completely repelling water and other solid particles. Although non-woven materials can capture fine particles, the microscopic pores of ePTFE membranes block virtually all particles, regardless of size or shape.

The ePTFE membranes are extremely thin at just 0.24mm, or less. But, perhaps most importantly, these membranes quickly and easily respond to sound waves, converting them into mechanical vibrations. Then, on the other side of the membrane, these vibrations are converted back into high-quality sound – and all this with 100% waterproof protection against anything from light rain to complete immersion.

Particular particulates

A second scenario that commonly arises is when particulate matter ingresses in to smartphone openings. It doesn't have to be as dramatic as dropping the phone at the beach. Everyday dust and dirt can also cause problems.

OEMs may combat this by placing a protective mesh over the acoustic openings, however, these are only able to capture larger particles that are bigger than the defined pore size of the mesh.

In-house testing at Gore claims that particle shape and surface area are more critical than pore size in determining the amount of protection a material can provide. For example, particles such as a human hair with a surface area equal to, or greater than, the specified pore size can still permeate the woven material due to its shape. What's more, any particles that are caught simply sit on the surface of the mesh and block airflow and reduce venting capability.

The benefits of non-woven material

Woven materials capture particles equal to or greater than a specified pore size, whereas non-woven materials capture a greater range of particle sizes and shapes.

Specialised methods and in-house environmental testing facilities at Gore show that non-woven materials catch particles across a range of shapes and sizes thanks to its 3D structure.

When made out of this material, vents can protect sensitive electronics from contaminants while still permitting any enclosure to 'breathe'. In this way, damage or device failure due to pressure differentials or ambient conditions are avoided.

This is a common problem for sealed

devices and can be split in to two main groups: rapid temperature changes caused by, for example, taking a device from a warm car into cold weather outside, and also air pressure changes such as taking off and landing in an aircraft.

When pressure builds in an acoustic cavity or chamber, it creates a bias on the transducer's compliant surfaces such as the speaker and receiver diaphragms. This can reduce acoustic output and eventually damage the transducer.

This is particularly the case if the device is equipped with waterproof transducers, as pressure vents are necessary to maintain high-quality acoustic performance. These prevent transducer bias by equalising pressure within the housing without compromising sound quality.

Early design collaboration

To be truly effective, acoustic and pressure vents have to be designed together at the early stage of a device's development. This helps to maximise acoustic performance while offering the best protection against water and particle ingress.

They should be designed specifically for portable electronics, using acoustically transparent materials that keep out external elements while relieving pressure inside the housing – and maintaining acoustic performance.

The vent dimensions are typically customised following the customer needs and requirements. However, vents are available in pre-cut shapes and sizes according to industry-standard dimensions for speakers, receivers, microphones and enclosures.

About the authors: *Victor Lusvardi is global sales leader and Oliver Teller is a product specialist at W. L. Gore & Associates' Portable Electronic Vents Business Unit.*

Colin Williamson **explains his plea to stop using biodegradable plastic: 'Please don't use them, don't recycle them and don't tell me how wonderful they are.'**

BAN THE BIO

In the 21st Century drive for sustainability, the concept of biodegradable plastics seems fantastic. The iconic man-made product reverting to nature seems too good to be true. And, of course, like anything that seems too good to be true, it probably is.

Biodegradable plastics do exist, of course, made from agricultural materials or made by modifying conventional petrochemical based materials. Now, for the sake of simplicity I have ignored the degradable plastics based on oil, as they use more energy than normal products as well as exhibiting the other problems mentioned below. But, rest assured, any claims of biodegradable plastic eco-efficiency are based more on politics and economics than mathematics. So let's look at the big picture.

Most scientists accept global warming is the biggest environmental threat to human life. We measure this by the carbon footprint over the lifecycle of a product or system. So, let's consider the carbon footprint of some plastics products by comparing the lifecycle of a biodegradable plastic bag or bottle with one made from 'traditional' oil based plastics.

Oil is pumped from the ground, refined into plastic and made into a product. It uses energy to make the transformation of course and this can be added to the energy embedded in the oil itself. Alternatively, corn is grown by a farmer who uses energy to drive his tractors and chemicals to spray the plants. After harvesting the corn is converted to a plastic product by an industrial process, which itself uses more energy.

We can calculate the total amount of energy expended in making a bottle or bag. If the packaging is oil based it probably weighs less than the biodegradable alternative so an allowance has to be made for this.

Few independent eco-audits have been conducted on biodegradable plastic products though, and we still have yet to discover the true eco-footprint made by agro-sourced plastics. Some bio-sourced plastics are based on a waste product from the agricultural industries, such as bagasse, and claim a zero carbon footprint, others are made from foodstuffs.

When the packaging has fulfilled its primary function it becomes waste, and that's where it gets interesting. Most waste in the UK ends up in landfill site, so let's consider what happens once the stuff gets buried. Oil based plastics may take centuries to degrade but until then they stay inert, just like a lump of rock or stainless steel. In other words they have no further effect on the environment. The biodegradable bag or bottle on the other hand starts to degrade relatively quickly (although nowhere near as quickly as the manufacturers claim – just try it if you don't believe me). It biodegrades, not just to carbon dioxide (CO2) and water as there is little oxygen in a landfill site, but to other chemicals that escape as complex molecules and gases, normally methane.

Methane is one of the powerful 'global warming' gases, about 24 times more damaging than CO_2. Recent EU directives relating to landfill sites acknowledge this by limiting and restricting the amount of biodegradables (especially garden refuse) going to landfill. There are other significant issues with biodegradables in landfills including land instability and leachates into the water table.

"So which is better, a bottle in a landfill site that has no further influence on the environment or one that biodegrades to a harmful global warming gas?" Colin Williamson has his say.

So which is better, a bottle in a landfill site that has no further influence on the environment or one that biodegrades to a harmful global warming gas?

What about recycling?

And as we recycle more and more waste, including plastics bottles and bags, one of the well-established uses of old polyethylene bags and film is to be recycled in to black builders' film to be used as damp-proofing. Imagine what would happen if biodegradable bags get mixed into this recycling stream.

The recycler can't differentiate between the biodegradable bag and the standard one so he makes and sells the sheets that then gets used under a floor in a new building. This is the ideal situation for degradation to start and the film develops a hole and no longer is a water barrier, the house gets a damp patch and no-one knows why. So the presence of biodegradable plastic carrier bags in the recycling waste stream is seriously impacting the recycling industry.

In some countries where biodegradable bottles have already been introduced, major problems are being encountered by the recyclers who have already taken billions of bottles out of the waste stream for recycling.

"Hang-on", I hear you say, "these biodegradable bottles can be put in the green waste collection bins to be composted?!" Well, yes, they can, but the guys doing the composting remove any plastic and discard it for landfill as they cannot differentiate biodegradable from traditional plastic.

Biodegradable plastics sound wonderful, but are largely a brilliant marketing concept. If landfilled they contribute greatly to global warming, if recycled they are a major hindrance to existing recycling schemes we have battled so hard to encourage.

Biodegradable plastics will have their uses, of course, but only when their end uses are clearly identified. One is as the bags for local authorities to collect garden refuse for composting. Ordinary polythene bags are normally used, but as they don't biodegrade, they have to be emptied of their contents, either by the collectors or at the composting facility. Biodegradable bags would be excellent for this application, able to be properly composted and unlikely to enter the recycling stream.

If you can think of any other suitable uses, please let me know, but until then: please don't use them, don't recycle them and don't tell me how wonderful they are.

About the author: *Colin Williamson is technical consultant at Smile Plastics, a dedicated plastics recycler.*

Laying it on

While additive manufacturing continues to be used to produce mould tooling, research is pushing towards production volumes of metal parts, while quirky low volume consumer design applications continue to surface. *Andrew Allcock* explains.

The additive manufacture of metal mould tools has been a well trodden path over several years, and that will continue, although in this first example the mould tool is a ceramic-filled plastic used in place of a machined metal one.

Swindon based Toolcraft Plastics – a long established plastic product mould toolmaking, injection moulding and vacuum forming firm – was looking for a quick turnaround injection moulding tool.

It sought a cost-effective and fast way to produce a very small number of mouldings. The company wanted to mount the tool in its standard machines, which normally use a steel or aluminium tool, to handle short runs of plastic injection mouldings and produce good results in a wide range of materials: ABS, polypropylene, TPE (thermoplastic elastomer) and PA (polyamide).

3D printing and rapid prototyping specialist firm Graphite Additive Manufacturing was approached to help deliver the solution.

A mould tool for Toolcraft's supermarket trolley coin (right) was 3D printed by Graphite, using a ceramic-filled plastic. The two-part mould was built by streolithography (SLA) at Graphite's base in Aylesbury, Buckinghamshire, within one day. By comparison, complicated metal tooling can take weeks to produce, while the cost would be much greater.

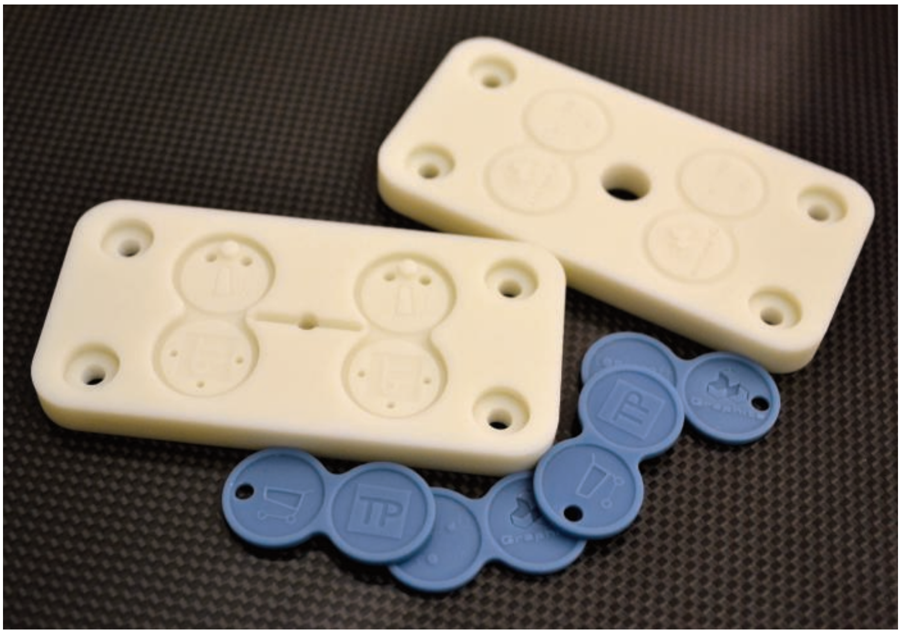
Toolcraft mounted the new 3D printed tool in a standard tool bolster and ran it in one of its automatic injection moulding machines. The results for the short production runs in each of the chosen materials were excellent.

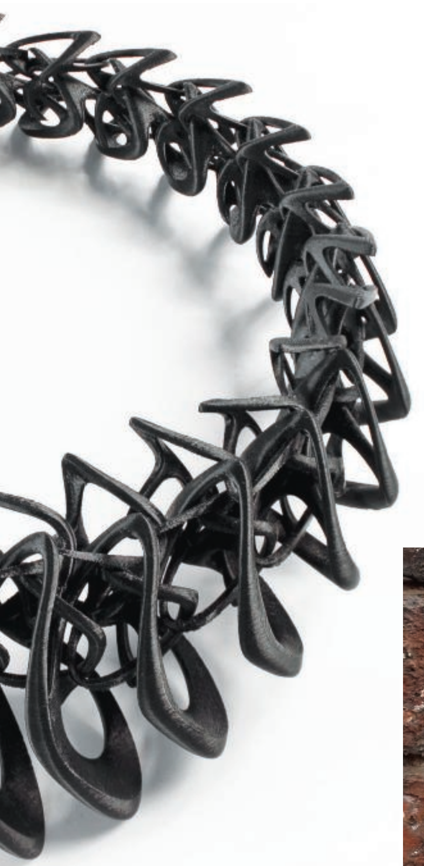
The ceramic-filled plastic tool does not have such a long life as a steel or aluminium one, but as a cost- and time-effective technique the process is ideal.

The 3D printed tool option is now offered by Toolcraft to customers having either very short run projects or those demanding an urgent turnaround.

Now, these plastic injection moulded parts could not themselves sensibly be created directly by additive manufacturing, of course. But looking to move direct metal additive manufacturing of components into the higher volume arena, and so avoid tooling production, is a new UK project, however.

High Wycombe-based CRDM, now owned by US-headquartered 3D Systems, is to lead a 30-month £1.25 million program to develop additive layer manufacturing (ALM) for production applications. The project consortium includes McLaren Automotive, Ultra Electronics, Delcam, Selex-ES and Flitetec, and is part funded through Innovate





“3D printing is no longer just a prototyping method, it’s a practical solution for producing highly complex one-off and small batch builds.” Chris Pockett, Renishaw

The supermarket trolley coin from Toolcraft (left); 3D printed jewellery inspired by organic movement (above) and the intricate luck and wish point sculpture made out of titanium (right)

UK, previously called the Technology Strategy Board.

Known as Automotive and Aerospace Part Production by Additive Layer Manufacture, or AA-PALM, the effort has three distinct goals: the automatic application of CAD correction techniques to ensure that ALM parts are manufactured with tolerance levels similar to traditional processes; the application of automatic finishing techniques to ALM components to provide aesthetic and mechanical properties that mimic traditional manufacturing and at costs that leverage the benefits of ALM; and to help OEM users develop Production Part Acceptance Procedures (PPAP), so that ALM parts can be directly accepted onto production lines. PPAP was pioneered in the automotive industry to establish confidence in component suppliers and their production processes.

The project includes ALM components manufactured in metals, polyamides and stereolithography resins. A key element is to deliver acceptable ALM parts at costs that are attractive, when compared to those manufactured traditionally.

“The economics of ALM have historically required that we consider parts that would be manufactured in low volumes and normally require tooling,” explains Graham Bennett, AA-PALM project leader. “However, even though this market is still quite considerable, recent developments suggest we may have an opportunity to expand our focus to higher volumes.

“Once we are able to use parts manufactured by ALM for production applications, we eliminate the requirement to produce costly tooling. Frequently, the large capital requirement of tooling costs acts as a barrier to new product introduction. We hope to address this problem, which, in turn, will make new product introduction a less costly affair.”

The project started producing deliverables late in 2014 and, by the end of the programme, the consortium is hoping to see ALM components regularly used in a variety of production devices.

Another UK additive manufacturing project was announced earlier last year at the Farnborough International Airshow. CADCAM specialist Delcam is to be part of a consortium of UK companies, lead by GKN Aerospace, which is undertaking a 3½ year, £13.4 million research and development programme called Horizon (AM).

The Horizon (AM) team includes GKN Aerospace, Renishaw, Delcam, and the Universities of Sheffield and Warwick. The programme is backed by the UK’s Aerospace Technology Institute (ATI) and funded jointly by industry and the UK Government’s Innovate UK.

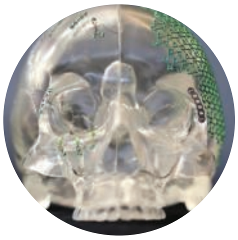
With its aerospace focus, Horizon (AM) will take a number of promising additive manufacturing techniques from research and development through to viable production processes, able to create components that could be as much as 50% lighter than their conventional counterparts, and which have complex geometries that cannot be manufactured cost effectively today.

These new processes are expected to unlock innovations in low-drag, high performance wing designs and in lighter, even more efficient, engine systems – and lead to dramatic reductions in aircraft fuel consumption and emissions.

Quirky examples abound

Aerospace is already fruitful ground for the application of additive manufacturing, of course, but there is also no shortage of ‘quirky’ applications for metal additive manufacturing, a process that clearly bridges the industrial and consumer worlds, offering designers a tool to produce their creations at, literally, the touch of a button.

For example, Renishaw’s technology has been put to use by those involved with the at the Triennial arts festival in Folkstone in



Engineering Materials' sister magazine, Machinery, along with The Journal of Hospital Medicine, is to present 'The Engineering-Assisted Surgery Conference' on the 20th May 2015 in London.

Sponsored by Renishaw, the one-day event will look at the use of additive manufacturing for reconstructive surgery. It offers additive manufacturing and engineering professionals the rare opportunity to mix with pioneering surgeons, NHS specialist and technology experts to share know-how and help steer the future of technology-based medical practice.

Book your place now at:

www.engineeringassistedsurgery.co.uk

Manufacturing end products

An article in Siemens' Pictures of the Future publication last year drew on research to give an overview of additive manufacturing (AM) and its future.

The article cited the latest research from world AM authority Wohlers Associates on market size and future growth, with comment from Bernhard Langefeld, a machine construction expert at Roland Berger Strategy Consultants.

Wohlers Associates says that the AM market had a size of €2 billion in 2012. And while it took the sector 20 years to reach a market value of €1 billion, the second billion was reached in only a further five years. Analysts now believe that it could grow at least fourfold over the next 10 years.

And while its roots are in the rapid prototyping of product designs, not direct manufacturing of products, it is direct manufacturing that is set to take off.

"Money will be made with manufacturing, not with prototypes," forecasts Tim Caffrey, a consultant at Wohlers.

Langefeld agrees, saying that industry is already close to the large-scale production stage in the use of AM to create metallic structures for selected products in medicine and aviation.

It goes on to say that AM is already a reality for making artificial hip joints and crowns for teeth, for example. And in another sector, Siemens is now printing burner tips from powdered steel for use as replacement parts for gas turbines.

The slow speed and expense of the process does, however, remains an issue, but, says Berger: "Manufacturers are now greatly increasing the machinery's efficiency. The latest generation of machines uses multiple lasers, larger build chambers, automatic changing systems and improved online monitoring features. Performance can be substantially increased as a result."

And faster processes mean lower unit cost of production. The manufacturing costs of printed metallic products will probably be cut in half over the next five years, adds Berger, and decline by another 30% in the five years after that. This assumes, however, that the current average build rate will increase eight-fold over the next 10 years – from 10 to $80cm^3/h$.

2013. Collaborating with Strange Cargo, the technology firm has produced 'the world's first recycling point for luck and wishes'.

For the installation entitled The Luckiest Place on Earth, Renishaw produced an intricately designed and sculpted luck and wish recycling point from titanium, using one of its AM250 additive manufacturing systems. The elaborately crafted titanium plaque incorporates a variety of lucky symbols into its design, including wish bones, horse shoes, clovers, shooting stars, black cats and more.

"We're incredibly pleased with how accurately our additive manufacturing machine has been able to reproduce Strange Cargo's unusual and alluring design for the luck and wish recycling point," enthuses Chris Pockett, head of communications at Renishaw. "The piece is yet another example of the potential of 3D printing when it comes to design freedom. 3D printing is no longer just a prototyping method; it's a practical solution for producing highly complex one-off and small batch builds."

Elsewhere, Jewellery designer Jenny Wu has launched her first 3D printed jewellery collection, Lace, in collaboration with 3D printing technology developer Stratasys. The designer's latest collection is, 'inspired by line-based geometry and organic movement'.

A key piece from the collection is the Tangens necklace, which features interlocking elements created by fused deposition modelling technology on the Stratasys Fortus 400mc Production System.

Wu also worked with Stratasys subsidiary Solidscape to produce the Papilio ring, a piece that reflects the movement of a butterfly wing.

Printed using Solidscape's MAX2 3D Printer, the ring was then cast in sterling silver and hand finished.

And staying with the jewellery theme, additive manufacturing technology firm EOS has launched Precious M 080 machine in collaboration with Cooksongold, part of the Heimerle + Meule Group, unveiling the new machine at the Hong Kong Jewellery and Gem Fair 2014.

Dr Keppler, chief marketing officer at EOS says: "This Additive Manufacturing process introduces an innovative and paradigm shifting technology to the luxury goods industry... Additive Manufacturing paves the way for a completely new approach towards design and manufacturing, enabling the design-driven manufacturing that the industry has long been searching for."

Using additive manufacturing, Cooksongold says it will support the most demanding jewellery brands in the creation of entirely new product lines that meet their high quality standards.

Additive manufacturing's strengths are exploited across both industrial and consumer markets, with its use in end product production set to grow.

The rise of non-standardised materials means the process of qualification has become a daunting and expensive task that's in danger of suffocating further innovation. *Chris Shaw* asks, is there an answer?

A question of **balance**

Historically, designing and managing materials for aerospace or defence applications meant viewing the process from a particular perspective. Most materials - for example aerospace alloys - were manufactured in bulk and subsequently shaped. It was usually sufficient to qualify the material properties, publish them in an authoritative source, and then engineers could apply them in varied designs across the board.

However, while it's still vital that engineers get hold of the right 'design allowable' data, Dr Will Marsden, director of industry relations at Granta Design, has identified two major developments to this world view.

"Firstly," he observes, "qualification has become more complex, particularly for

Boeing's 787 Factory in Everett, Washington (main) The manufacture of the Dreamliner cockpit (below)

"We need to qualify the material in combination with specific processes, geometries, and conditions." Dr Will Marsden, Granta Design

materials such as composites and areas like additive manufacturing. We need to qualify not only the material, but the material in combination with specific processes, geometries, and conditions, as well as qualifying the supply chain and even the operative making the material.

"Secondly, as materials become better understood, there is even more focus on extracting maximum performance from them for specific applications – so fine tuning material properties in every area of a component. For example a turbine blade that uses differential heat treatments with greater control over process parameters."

Light flight

The aerospace and defence sectors are plagued by weight and cost reduction issues. Nevertheless, there are a number of materials available, with the greatly increased use of composites being the clearest trend. Most notably the Boeing 787 used more composite materials in its airframe and primary structure than any previous Boeing commercial aeroplane.

The airframe, which comprises nearly half carbon fibre reinforced plastic, achieved a 20% weight saving compared to conventional aluminium designs.

To determine the best materials, Boeing engineers analysed every aspect of the airframe, its operating environment and component loads over its lifespan. So, while composites aren't as efficient in dealing with compression loads as aluminium, they are excellent at handling tension and the material was therefore used extensively in the fuselage. This reduces fatigue based maintenance compared to an aluminium structure.

Similarly, titanium is used as a low maintenance design solution, as it can withstand comparable loads better than aluminium, has minimal fatigue issues and is corrosion-resistant. Around 14% of the Boeing 787's airframe comprises of titanium.

"Composites can make significant contributions to weight reduction," Marsden notes. "Whether they drive cost reduction depends, of course, on whether you are concerned with the materials and manufacturing costs or the full lifecycle costs of the aircraft. Since fuel burn costs are a

AMAZE Project

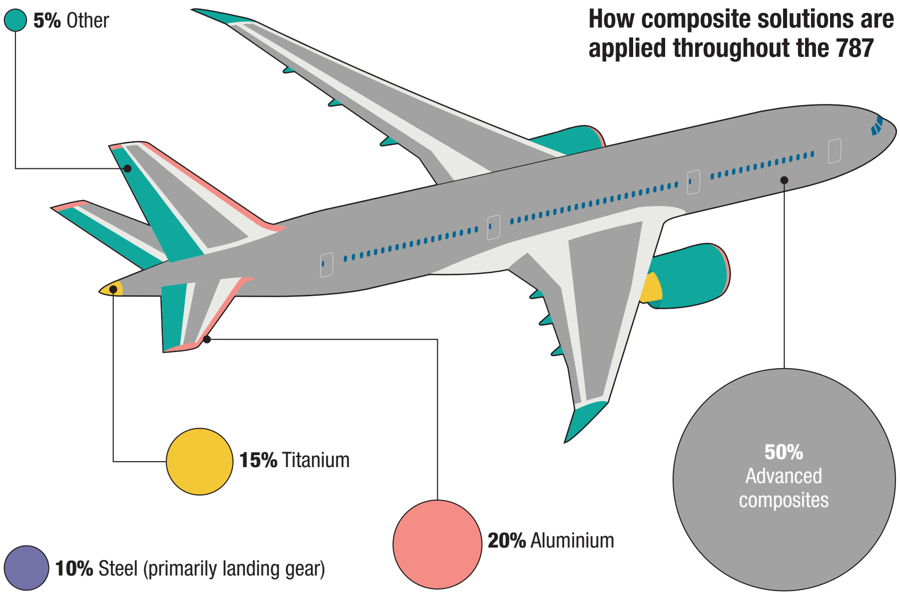
The €20 million AMAZE project is coordinated by the European Space Agency for the rapid production of additive manufactured metallic components up to 2m in size, with zero waste. Targeting aerospace/defence industries, four Europe-based industrial centres will be built by 2016 with the aim to start production of high value parts, while halving the cost of traditionally processed finished parts.

The project will see an increase in the commercial use of adaptronics, an adaptive structure technology, based on functional integration and designed to optimise structure systems.

Combining conventional structures with these systems extends load bearing and form defining structure performance by including sensor and actuator functioning. When combined with adaptive controller systems, they can adapt to their respective operational environment. The aim of the adaptive structure technology is to influence structures and allow users to optimise products.

In order to turn additive manufacturing into a mainstream industrial process, the AMAZE project will focus on pre-normative work, standardisation and certification, in collaboration with ISO, ASTM and ECSS standards bodies.

How composite solutions are applied throughout the 787



There is still a reluctance to use composites, primarily because the qualification process has become increasingly expensive

major contributor to the latter, lower weight usually 'wins out' on this basis too.

"Where fuel costs matter, running engines at a higher temperature can also help, by making the engine more efficient. Material innovations can be required here, such as the use of ceramic matrix composites. And new manufacturing techniques like additive manufacturing hold out the prospect of further weight reductions by enabling engineers to realise designs for non-structural components such as brackets that minimise the amount of material used by shaping the part so that it only has material on the load-bearing paths."

However, there is still a reluctance to use composites, primarily because the qualification process has become increasingly expensive. Whereas a few years ago qualifying a material might have cost $3 million and taken six years, costs of up to $100 million are now quoted and, Marsden warns, with no real improvement in time-to-market.

"Composites are still a relatively new technology," he asserts. "They fail in ways that aerospace engineers are not familiar with and we still need better design tools to develop a deep understanding of their performance and application. All of this means aluminium alloys remain a common choice for commercial aircraft.

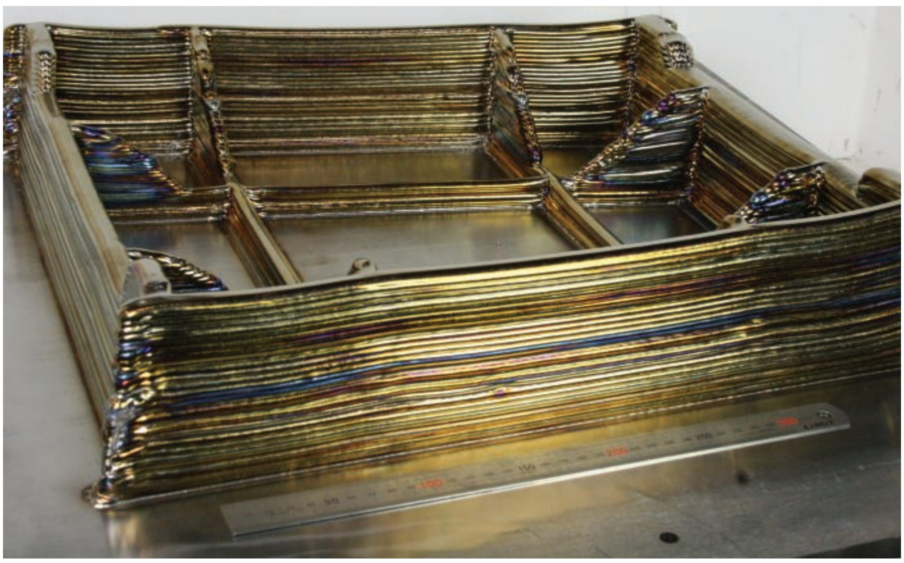
"Managing data about composites is an important factor here. Doing this effectively is essential to reducing qualification times, avoiding risk in the process, and delivering the right input data for design tools."

Composites, however, are a mature technology relative to additive manufacturing, which is still in its infancy. There are, as yet, no additively manufactured parts qualified to fly and much R&D is still needed to understand how to qualify them and lower production costs.

"Again, materials data management has an important role to play," says Marsden, "since capture and analysis of large quantities of data is integral to R&D programmes, such as the AMAZE project."

And, because an aerospace and defence design engineer's job is to balance functional requirements with constraints, it's easy to see why trade-offs are endemic in materials selection.

Composites and additive manufacturing technologies could offer a potential solution here, by enabling designers to arrive at an optimum choice of structural concept and material selection for a given weight. But, like everything, that will not come cheap.



Additive manufactured parts (below) offer great potential for weight reduction but are proving difficult to qualify for flight

The emerging discipline of ICME

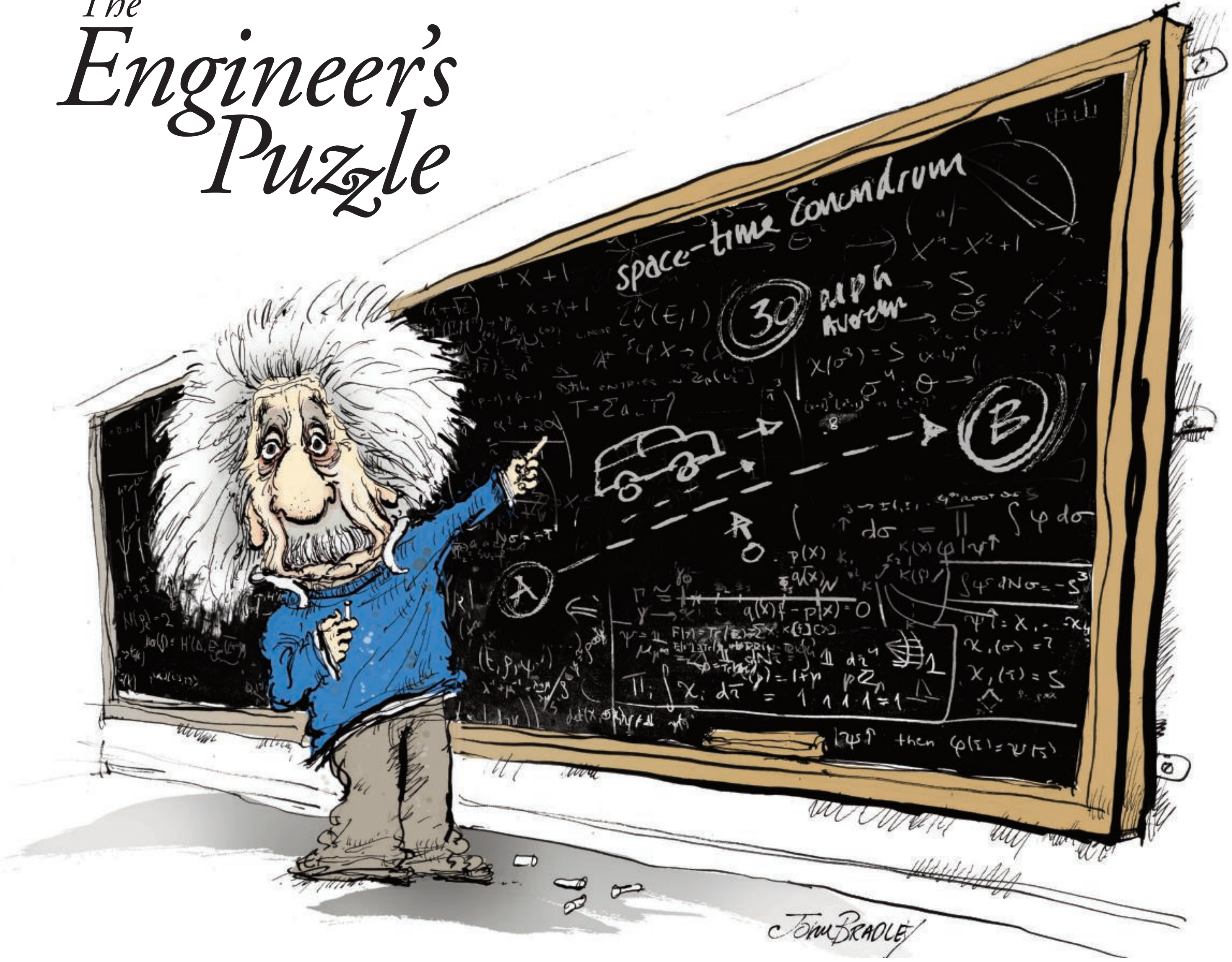
As well as composite data management, Integrated Computational Materials Engineering (ICME) looks set to have a major impact on the aerospace/defence materials design process.

As an emerging discipline, it seeks to apply computational methods at multiple length scales, validating the results and applying them to understand and improve materials performance.

Different, complementary, simulation methods are applied in support of each other, to study and predict processes, structures, and properties - and their interactions with each other.

"The aims are to gain insight and design better materials, faster, while reducing reliance on expensive experimentation," says Dr Will Marsden, director of industry relations at Granta Design. "Again, effective management of materials information is vital to ICME projects to capture the results of one simulation (materials properties, structures, or processes) and apply them as inputs to another."

The Engineer's Puzzle



Driving me MAD!

Two engineers are arguing. They'd read a puzzle in *Engineering Materials* magazine and were trying to convince one another that THEY were right!

The puzzle went along the lines of this: If you drive halfway to a town 60 miles away at a speed of 30mph (assume any time lost for acceleration or deceleration is negligible), how fast would you need to drive the rest of the way to have an average speed of 60mph over the entire trip?

You need to travel to the town directly (assume a straight line) from your half way position, and once there, you stop and turn off the engine.

Now, the two engineers 'discussing' this have very different views. One says: "It's 90mph you buffoon!" While the other replies: "You idiot, it can't be done. It's impossible!"

The question is: who, if either, is right?

For the Engineer's Puzzle answer visit www.materialsforengineering.co.uk