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Image: Carboman Group, a French company that prototypes and makes composite structures, is collaborating with electric air transport company Eviation Aircraft to make an all-electric aircraft structure. The Eviation Alice uses the lightest possible carbon fiber composite airframe with a 650-mile range using a sustainable, low noise and zero-emission electric propulsion system, the company says.

REGULAR SECTIONS

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FEATURES

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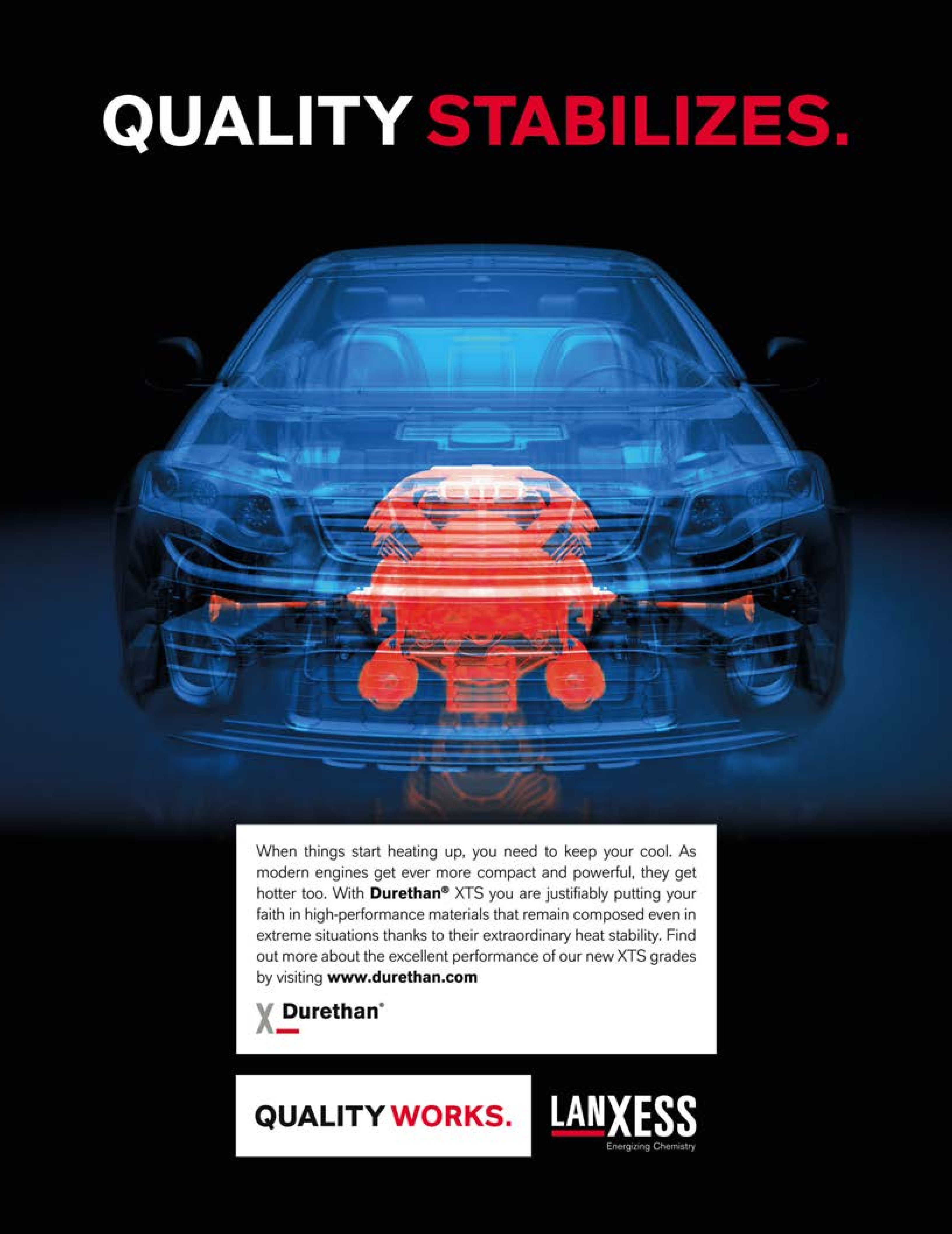
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Durethan®
QUALITY WORKS.
LANXESS
Energizing Chemistry

RP Rewind

Liz Nickels leafs through past issues of Reinforced Plastics to find out what was happening in the PM industry of the past.

Five years ago. . .

We reported that NASA scientists were developing a prototype composite flying wing aircraft which they said could be used to fly in the Martian landscape. According to Al Bowers, NASA Armstrong chief scientist, the aircraft would be made of either glass or carbon fiber composite material.

Plans were for the Preliminary Research Aerodynamic Design to Land on Mars (Prandtl-M), to be launched from a high-altitude balloon later in the year.

'The aircraft would be part of the ballast that would be ejected from the aeroshell that takes the Mars rover to the planet,' Bowers said. 'It would be able to deploy and fly in the Martian atmosphere and glide down and land. The Prandtl-M could overfly some of the proposed landing sites for a future astronaut mission and send back to Earth very detailed high-resolution photographic map images that could tell scientists about the suitability of those landing sites.'

Not much was heard on this project until two years later, in March 2017, when NASA reported that flight tests of the Prandtl-M had resumed, while 'student interns with support from staff members at NASA Armstrong Flight Research Center' were working on improving the shape of the aircraft and the systems required for it to fly autonomously and gather the required data.

10 years ago. . .

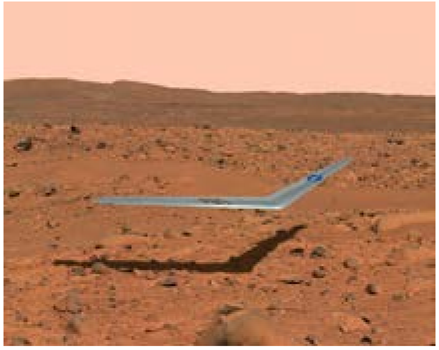
Wind power installations for the first six months of 2010 dropped by 71% from last year's level, according the American Wind Energy Association (AWEA). The association also predicted that total 2010 installations would be 25–45% below 2009 installations, depending on policy developments. Combined first quarter (Q1) and second quarter (Q2) wind energy installations in 2010 were 1239 MW, 57% below 2008 half-year levels and 71% below 2009.

Fast forward to 2018 and the industry, if not the environment, is looking healthier, as the AWEA reported that US wind power grew 8% in 2018 amid record demand. The industry now supports 114,000 American jobs, over 500 domestic factories, and more than US$1 billion a year in revenue. 'Wind power's record-breaking year shows our industry is leading the way to a cleaner, stronger 21st Century US economy,' claimed Tom Kiernan, CEO of AWEA.

20 years ago. . .

We focused again on composites in the US with William K Hamilton speaking to John Tickle, president of pultrusion specialist Strongwell. 'The composites business has an ever-so-promising future,' said Tickle. 'Trouble is, those in the business first have to deal with an ever-so-difficult present. That's been the situation forever.

'While North America may be the biggest user of composite materials – both in total tonnes and on a per capita basis – there is still plenty of opportunity there. Our slice of the pie is still very small compared to the overall opportunity to replace other materials. To keep growing, we need to remember that our competition is those other materials.'



A NASA illustration showing what the Prandtl-M composite aircraft might look like flying above the surface of Mars. (Photo courtesy NASA Illustration/ Dennis Calaba.)

1369-7021/https://doi.org/10.1016/j.repl.2019.08.039

Applications

Light carbon fiber aircraft

Carboman Group, a French company that prototypes and makes composite structures, is collaborating with electric air transport company Eviation Aircraft to make an all-electric aircraft structure.

The Eviation Alice uses the lightest possible carbon fiber composite airframe with a 650-mile range using a sustainable, low noise and zero-emission electric propulsion system, the company says.

The Eviation Alice uses the lightest possible carbon fiber composite airframe.

Carboman has also announced plans to expand its aerospace tooling and components production using new five-axis computer numerical control (CNC) equipment acquired from Brittany-based composite tooling specialist SNE-SMM in 2017. The company will also add a new aerospace certified 2.2 m × 6 m 250 °C 10 bar autoclave at its Ecublens site.

Carboman Groupe; www.carboman.eu

0034-3617/https://doi.org/10.1016/j.repl.2019.08.004

Innovative rocket makes use of composites

A team from the Colorado State University (CSU) has developed a composite rocket for the 2019 Intercollegiate Rocket Competition (IREC) competition.

With a payload size of 8.8 lbs and target altitudes of either 10,000 or 30,000 feet above ground level, competing rockets are typically 4–8 in in diameter and 8–20 ft long. Multistage rockets and all chemical propulsion types (solid, liquid, and hybrid) are allowed.

As a part of improving the rocket design, the student team replaced the current glass fiber fuselage with one made using filament winding and carbon fiber. The team wound the rocket fuselage using LCWR-1.2 (a two-component epoxy winding resin) donated by Lattice Composites, and carbon fibers donated by Composites One.

According to Composites One, filament winding is a suitable manufacturing process for the CSU rocket because it places fibers around the circumference of the tube to produce parts with high strength.

According to Composites One, filament winding is a suitable manufacturing process for the CSU rocket because it places fibers around the circumference of the tube to produce parts with high strength. Filament winding also provides the capability to use very long continuous fibers to add additional strength and reduce overall lower cost when compared to prepreg composite options.

Composites One;
www.compositesone.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.005

Luxury aircraft interiors

TRB Lightweight Structures has supplied a range of panels to make luxury suites for the interior of Singapore Airlines' aircraft. The Skyroom suites are on board five new Airbus A380 passenger aircraft and were commissioned to celebrate the airline's 70th birthday.

TRB says that it was commissioned by aircraft manufacturer Saftan to provide over 100 different complex, press-cured phenolic panels. The design of each room was dependent on its position within the aircraft, requiring the production of different types part. Each panel also needed to be supplied with a cure graph, and to vigorous quality assurance checks to ensure a high standard finish.

TRB Lightweight Structures has supplied a range of panels to make luxury suites for the interior of Singapore Airlines' aircraft.

TRB will also manufacture over 100 doors as part of an ongoing scheme to fit Skyroom suites to the rest of the Singapore Airlines Airbus A380 fleet.

TRB;
www.trbls.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.006

Composite surfboards run faster

Composites manufacturer Cobra International and Flite, an Australian-based surfboard manufacturer have joined forces to develop two electric foiling composite surfboards that can reach speeds of up to 45 km/h.

Fliteboard and Fliteboard PRO boards, which can reportedly fly above the water with a zero-emission propulsion, incorporate a carbon/Innegra prepreg expanded polystyrene (EPS) sandwich laminate. The electric and electronic components are contained in a watertight thermoformed carbon battery box with a full carbon sandwich lid. Each board weighs between 22 and 28 kg, depending on board, battery and wing choice.

Fliteboard and Fliteboard PRO boards can reportedly fly above the water with a zero-emission propulsion.

Cobra also carried out developmental work on the foils and accessories for the Flite range and the foils are now manufactured by the company, along with the deck pads and board bags.

The company says that it has now begun production and will produce approximately 600 units throughout 2019.

Cobra International; www.cobrainter.com

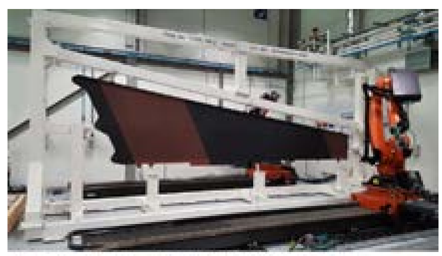
0034-3617/https://doi.org/10.1016/j.repl.2019.08.007

Spirit AeroSystems collaborates on wing project

Spirit AeroSystems says that it will be participating in Airbus's Wing of Tomorrow program, which is aimed at developing materials, manufacturing and assembly techniques in aerodynamics and wing architecture.

The company plans to focus on the fabrication and assembly of leading edges, wing boxes and lower wing covers.

One of the projects involves using composite resin-flow simulation tools to infuse a 7 m lower wing cover as part of a demonstration project. According to Spirit, the demonstrator is a major step towards delivering a full-scale, resin-infused lower cover to Airbus.



The 7 m lower wing cover demonstrator during inspection.

'These projects are not just about composite infusion technology,' said Spirit AeroSystems vice president Sean Black. 'Using digital design and manufacturing approaches, we're developing the product in parallel with the production system. In collaboration with the National Composites Centre and Advanced Forming Research Centre we're also developing highly automated fabrication and inspection technologies. In addition, we are implementing significant advances in fabrication and assembly tooling technologies.'

Spirit AeroSystems; www.spiritaero.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.008

US Air Force commissions CF 3D printed part

The Utah Advanced Materials & Manufacturing Initiative (UAMMI) has reportedly created its first carbon fiber thermoplastic 3D printed part for the United States Air Force – a first aid kit restraint strap for the B-1 aircraft. The part was made using a 3D printer from project partner Impossible Objects.

UAMMI was awarded federal funds to create carbon fiber additive manufactured parts for the US Air Force in 2018. The aim was to replace broken parts on older legacy aircraft as most original parts are no longer produced.

In many B-1 aircraft, the Air Force experienced failures with original restraint straps, Impossible Objects says. As original replacement straps are no longer manufactured, there can be significant costs and wait time to have new parts produced through traditional means.

The first carbon fiber part 3D printed for the US Air Force: a first aid kit restraint strap for B-1 aircraft. (Photo courtesy Business Wire.)

'Additive manufacturing represents a huge opportunity for Utah's advanced manufacturing industry,' said Jeff Edwards, UAMMI executive director. 'The composite additive parts that we are creating for the Air Force will significantly reduce both the time and cost of aircraft repairs.'

Impossible Objects; www.impossible-objects.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.009

Composite helicopter components

GKN Aerospace says that it has produced two thermoplastic composite induction welded ruddervators, and two compression-molded access panels manufactured from re-used thermoplastic waste material, to aircraft manufacturer Bell Helicopter for its Bell V-280 Valor craft.

Ruddervators are the control surfaces for an aircraft with a V-tail configuration, according to GKN. The two compression-molded access panels were manufactured from recycled thermoplastic waste material from the two ruddervator. The various components are technology demonstrators and are planned for flight testing on the aircraft in 2019. This will make the V-280 one of the first military aircraft flying with thermoplastic components, the company says, adding that thermoplastics can offer advantages in terms of weight, costs, production time and environmental impact.

The Bell V-280 Valor craft. (Photo courtesy Bell Helicopter.)

GKN;
www.gknaerospace.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.0010

Hybrid composite transport part

Engineers at Performance Engineered Solutions (PES) Ltd in the UK are developing a hybrid composite-metal anti-roll bar for trucks and trains.

The project has been co-funded by the UK's innovation agency, Innovate UK, Tinsley Bridge Ltd, which supplies anti-roll bars, and the University of Sheffield Advanced Manufacturing Research Centre (AMRC).

According to the companies, lighter composite anti-roll bars could cut fuel consumption and emissions from rail and heavy road vehicles, when compared to traditional metal bars.

A previous project recorded 65% reduction in the weight of the stabiliser bar by replacing the current solid steel component with a carbon fiber composite member without compromising performance, the AMRC says. The new project will develop the design of the anti-roll bars and undertake simulation tests using Finite Element Analysis (FEA).

The AMRC's Composite Centre has produced the anti-roll bar prototypes using its MF Tech filament winding system. It also used its CT scanner capability to inspect the inside of the bar, checking the structural integrity and verifying the build quality.

Engineers are developing a hybrid composite-metal anti-roll bar for trucks and trains.

'Carbon fiber composites are commonly used in high-end supercars, but have yet to see widespread use in the volume automotive sector,' said PES Performance engineering director, Dean Gardner. 'This project aims to show the wider benefits that these materials can provide.

'One of the major challenges has been to achieve a strong and durable interface between the materials in the hybrid anti-roll bars design, in order to achieve the required fatigue performance. With our experience in lightweighting and composites, it is good to be working with Tinsley Bridge and the AMRC on this exciting, potentially ground-breaking project.'

AMRC;
www.amrc.co.uk

0034-3617/https://doi.org/10.1016/j.repl.2019.08.0011

Lightweight composite auto parts

Lanxess says that its continuous fiber reinforced material has been used to make a range of structural components for the Audi A8 sedan car.

The car features two electrically adjustable individual rear seats made with a hybrid molding process using the company's polyamide-6-based Tepex dynalite 102-RG600(2)/47% material. Lanxess' short glass fiber reinforced Durethan BKV30H2.0 polyamide 6 is used as an over-molded material.

'The reason that our composite material was chosen for this structure was the fact that it is around 45% lighter than a comparable metal design but can also be produced cost-effectively, thanks to the high degree of functional integration,' said Henrik Plaggenborg, head of Tepex Automotive at Lanxess. 'It can also withstand the high mechanical loads in a crash.'

Tepex dynalite 102-RG600(2)/47% is around 45% lighter than a comparable metal design. (Photo courtesy Lanxess AG.)

According to the company, similar seats have mainly been made using metal shells screwed onto a substructure, but manufacturing the metal shells can be time-consuming as they consist of numerous individual parts that have to be joined together by means of welding in several steps. 'In the hybrid molding process, by contrast, a ready-to-install component is created in a single process step,' said Tilmann Sontag, project manager at the Tepex Automotive group. 'The pre-contoured and heated semi-finished composite product is formed directly in the injection molding tool for this purpose, and equipped with numerous functions by means of injection molding.

Besides the reinforced ribs, the piping groove for securing the seat cover in place as well as numerous holders and guides for seat ventilation and cable holder are integrated into the component. The clips to attach the seat shell are also directly injected.

Lanxess;
www.lanxess.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.0013

Improved Hyperloop pod is even faster

SGL Carbon has supported students at the Technical University of Munich to develop a prototype pod for the Hyperloop transport system.

In 2018, the university launched a pod which 2018 which flew through the 1200 m test tube at a velocity of 467 km/h. This year, the focus is on speed and stability. To expedite this, the team chose woven carbon fiber prepreg material with mounts for the shell built completely out of carbon, cutting the weight in half from 1.5 kg to 700 g.

Students at the Technical University of Munich are developing a prototype pod for the Hyperloop transport system.

In all, the carbon component of the current pod weights around 10% less than the previous model (5.6 kg compared to 6.1 kg).

SGL;
www.sglcarbon.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.0014

Lightweight supercar

Royal DSM and UK supercar manufacturer Briggs Automotive Company (BAC) plan to develop 3D printing applications for the new BAC Mono R vehicle.

According to the companies, integrating 3D printing in car manufacturing helps create parts that are not only lighter, but also stronger and customizable. Additive manufacturing (AM) technology can also enable original equipment manufacturers (OEMs) to explore new designs that would be impossible to produce using traditional manufacturing methods.

The new Mono R features 3D-printed customizable grips for the Mono R's steering wheel and air inlets that are reportedly lighter, more durable, and more cost-effective to produce than traditional inlets. BAC and DSM were able to limit the weight of the new supercar to 560 kg.

The BAC Mono R features new, 3D-printed air inlets that are reportedly lighter, more durable, and more cost-effective to produce than traditional inlets.

The companies now plan to explore the design and production of 3D-printed parts incorporating organic shapes and hollow internal structures and make use of newer and recyclable materials.

DSM;
www.dsm.com

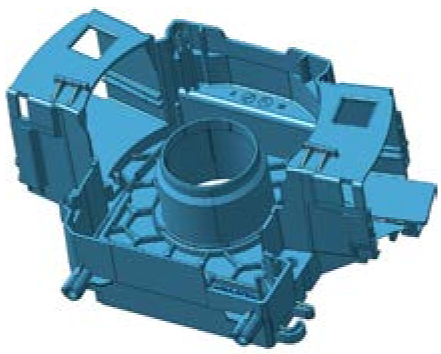
0034-3617/https://doi.org/10.1016/j.repl.2019.08.0015

Steering column switch housing made from polyamide 6

Lanxess says that it has successfully replaced reinforced polyamide 66 with reinforced polyamide 6 to make a steering column switch housing in a number of Ford vehicles.

According to the company, changing the material to Lanxess' Durethan BKV30H3.0 polyamide 6 with 30% by weight glass-fiber reinforcement used the same tool as for polyamide 6.

The housing was also injection molded from foamed polyamide 6 which can save material and weight when compared to solid components with some compromises in terms of mechanical characteristics, Lanxess says. As well as this, the foaming leads to a reduction in warpage and shrinkage, which can improve the dimensional accuracy of the component.



Substitution of polyamide 66 with polyamide 6 Durethan BKV30H3.0 in a steering column switch housing for different vehicle models from Ford.

Lanxess; www.lanxess.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.0016

Supercar features graphene-enhanced composites

Haydale Graphene Industries says that its prepreg material incorporating graphene powder forms part of the composite tooling and automotive body panels of the Briggs Automotive Company (BAC) Mono R supercar.

According to the company, using graphene-enhanced composites rather than metal means that the coefficient of thermal expansion (CTE) is more closely matched, while composite tools without graphene can also have a finite life due to wearing of the tool surfaces and microcracking.

'In the development of this project, Haydale has improved the supply chain and cycle times as well as enabling BAC to reduce weight and increase performance of the material,' said Keith Broadbent, CEO at Haydale. 'Whilst this outcome has focused on the automotive sector, the knowledge and improvements made provide a wider opportunity for tooling materials across several markets, particularly where there are throughput constraints.'

The Briggs Automotive Company (BAC) Mono R supercar.

Haydale Graphene Industries; www.haydale.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.0017

SGL Carbon delivers millionth glass fiber leaf spring

SGL Carbon says that it has delivered its millionth glass fiber reinforced plastic (GFRP) leaf spring, used in a car's suspension.

According to the company, while standard steel leaf springs can weigh up to 15 kg, a similar GFRP spring leaf weighs 6 kg, making it around 65% lighter. It also reportedly requires less space and has easier handling, while the composite design means the leaf spring can be tailored to different models.

'The new leaf spring allows a significant weight saving in our vehicle models compared to conventional steel springs in this application,' said Erik Johansson, senior design engineer at Volvo Cars. 'This contributes to lower fuel consumption and reduced CO_2 emissions. In addition, we can use a small number of leaf spring variants in many different models.'

SGL Carbon; www.sglgroup.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.0018

Lightweight panel for building

Diab says that it has teamed up with a Spanish building company to develop a sandwich lightweight panel for building façades.

Butech, part of the Porcelansa Group decided to develop the panel for various reasons, including reduced weight. The System X light XXL features a fixing solution for façades with a ceramic facing and an aluminum backside with a core of Divinycell P that for thermal insulation. The panel, which is 3000 × 1000 mm, complies with the Euroclass Bs2d0 fire, smoke and toxicity classification.

Diab; www.diabgroup.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.0019

Lower cost CF aerospace parts

Spirit AeroSystems says that it has developed a new way to produce carbon fiber composite materials that could lower costs and increase production volumes of future aircraft components. It has developed the Advanced Structures Technology and Revolutionary Architectures (ASTRA) panel, a full-scale demonstration fuselage panel using the new technology.

In one example, Spirit's integrated sheet stringer, an internal fuselage support component, can be formed in place, eliminating many current processes, according to Spirit AeroSystems senior director of research and technology Eric Hein. 'This includes a separate stringer forming line and elimination of multiple tools,' he said.

The seamless sheet stringer and skin can provide smooth, continuous surfaces for attaching frames and other hardware, while weight savings can be achieved by more efficient application of composite fiber tape placement, according to Hein. 'Non-vented bladder systems used in the aerostructures manufacturing process improve quality, and low-cost production tooling reduces overall new program costs,' he said.

Spirit says that it is also using a new composite material, Toray T1100/3960, that can improve structural performance, and QISO braided fabric made by A&P Technology, which has improved formability.

Spirit Aerosystems; www.spiritaero.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.0020

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Business

Update for natural fiber report

Researchers at nova-Institute, an organization which supplies biomaterial-based information, have updated its 57-page study entitled 'Carbon Footprint and Sustainability of Different Natural Fibers for Biocomposites and Insulation Material'.

The study was initially conducted in 2018 and the update has been published with new findings and processes covering the hemp supply in Europe and kenaf supply in Bangladesh.

Natural fibers such as flax, hemp, jute or kenaf are used in large quantities in the automotive industry to reinforce plastics, the organization said. The carbon footprint of natural fibers such as flax, hemp, jute or kenaf is much lower than their counterparts glass and mineral fibers.

The report can be downloaded at the www.bio-based.eu website.

Nova-Institute;
www.nova-institute.eu

0034-3617/https://doi.org/10.1016/j.repl.2019.08.022

Solvay forms AM partnership

Solvay has announced an agreement with polymer 3D printing company Stratasys to develop additive manufacturing (AM) filaments for use in Stratasys' 3D printers.

The AM filament will reportedly be based on Solvay's Radel polyphenylsulfone (PPSU) polymer and will meet FAR 25.853 compliance requirements for use in aerospace applications. Both companies aim to commercialize the filament in 2020.

Radel PPSU grades are suitable for use in aircraft cabin interior components and are compliant with all commercial and regulatory requirements for flammability, smoke density, heat release, and toxic gas emissions, the company said.

'The combination of Solvay's materials' selection and expertise with Stratasys' high quality, repeatable 3D printing capabilities will open up new possibilities for additive manufacturing in more of the industries that we serve today for 'traditional' manufacturing,' said Christophe Schramm, business manager at Solvay.

Solvay;
www.solvay.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.023

Arburg expands Thailand base

Injection molding specialist Arburg has opened new premises in Samutprakarn, Thailand.

'We are very proud to have the largest Arburg showroom in Southeast Asia because of the new premises,' said MD of Arburg Thailand Ratree Boonsay, who has managed the subsidiary since its foundation in 2001.

'The positive development over the past decades confirms that we chose the right path and that our continuous investments in the important Asian market have paid off,' added director of overseas sales Andrea Carta.

Inauguration of the new Arburg premises. From right: Andrea Carta, Ratree Boonsay and Dr Alexander Raubold, counsellor economic and commercial affairs of the German embassy in Bangkok. (Photo courtesy Arburg.)

Arburg in Thailand was initially been managed by a representative office of Arburg Pte Ltd. In 2001 Boonsay took over the management of the newly founded subsidiary.

Arburg;
www.arburg.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.024

Researching aqueous polymer dispersions

Polymer company Covestro is working with the Technical University of Cologne to investigate how to improve aqueous polymer dispersions.

The dispersions are used as liquid raw materials in paints and coatings, adhesives and other everyday products, the company says. The project, entitled 'Applied Research on Disperse Colloidal Polymers' is being funded over a period of three years for around €600,000.

Covestro makes polyurethane dispersions (PUDs), which consist primarily of water and a polyurethane finely dispersed in it. They are mostly used as film formers or binders in paints for the initial and refinishing of automobiles, in wood/furniture paints and floor coatings, as well as in textile coatings and glass fiber coatings.

'Paint and adhesive manufacturers all over the world are increasingly opting to replace solvent-based products with more sustainable aqueous systems such as polyurethane dispersions (PUDs), provided they have the same excellent properties,' said Michael Friede, global head of the coatings, adhesives and specialties segment.

'The goals of the project are the optimization of manufacturing processes, an improved understanding of structure-property relationships and the development of new applications for the dispersions,' said Dr. Jan Weikard, PUD expert at Covestro.

Covestro;
www.covestro.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.025

Nouryon announces new structure

Chemicals company Nouryon has announced a new organizational model as part of its strategy to improve growth and performance.

The new model, which will take effect at the beginning of 2020, is organized around three market-focused businesses supported by a centralized operations and functional structure, the company said.

The three businesses are Technology Solutions, managed by Johan Landfors, formerly MD OF Polymer Chemistry; Industrial Chemicals where Knut Schwalenberg continues as president and Performance Formulations with a president named at a later date.

'This optimized model will allow our businesses and support organizations to concentrate on what they do best,' said Charlie Shaver, Nouryon CEO. 'Each business will have a clear mission, driving management focus.'

Nouryon;
www.nouryon.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.026

New chair of Composites Leadership Forum

The Composites Leadership Forum (CLF) says that Ken Smart, executive director of business strategy for McLaren Automotive, will take over the role of chair.

He takes over from Alex Aucken, previously global automotive director, Solvay, following the completion of his term of office.

Smart led the project team responsible for establishing the £50 million McLaren Composites Technology Centre (MCTC) and has now been promoted to the company's executive team. Before joining McLaren, he was MD of three aerospace and defence companies.

Ken Smart, executive director of business strategy for McLaren Automotive, will take over the role of chair of the CLF.

'It's a great honour to be appointed as the new chair of the Composites Leadership Forum at such an important moment for the sector,' said Smart. 'The UK automotive industry recognises the importance of work to reduce overall vehicle weight which, when combined with future powertrains, will be vital to delivering the future mobility solutions needed. This is an area where the UK can develop world-leading, truly innovative solutions applicable for automotive, aerospace and defence applications.'

Composites UK;
www.compositesuk.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.027

Kordsa opens US$18 million polyester yarn line

Kordsa has opened a new polyester yarn production line at its İzmit facility in Turkey to meet increasing demand in the field.

The company also plans to open a new facility in Indonesia and could enable 7000 tons of additional capacity in each plant in 2016, Kordsa said. The products reportedly have high resiliency and improved dimensional stability.

'Our latest investments enabled us to strengthen our position among the largest polyester yarn producer and provided us another leadership in polyester yarn,' said Kordsa CEO Ali Çalışkan.

Kordsa;
www.kordsa.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.028

SAMPE elects new leaders

The Society for the Advancement of Material and Process Engineering (SAMPE) has elected its 2019–2020 global officers.

Professor Kazuro Kageyama from the Kanazawa Institute of Technology, Tokyo, Japan, has been appointed as the organization's global president.

Also elected to serve as global executive vice president is Dr Ing Xiaosu Yi, FSAMPE, University of Nottingham, Ningbo, China. SAMPE Global's current president, D. Brent Strong, FSAMPE, will support Professor Kageyama as the global immediate past president.

'It is a significant honor to serve all of our SAMPE members as your global president,' Professor Kageyama said.

SAMPE; www.sampe.org

0034-3617/https://doi.org/10.1016/j.repl.2019.08.029

Materials development for 3D

Evonik and Evolve Additive Solutions Inc have announced a joint development agreement to adapt Evonik's thermoplastic materials for use in Evolve's 3D printing systems.

The companies reportedly plan to focus initially on polyamide 12, polyether block amide (PEBA), transparent polyamide and polymer of the polyamide 6 series.

'Evolve's entirely new technology approach will allow us to expand the range of applications of our high-performance materials, which are produced through a unique production process,' said Thomas Grosse-Puppendahl, head of additive manufacturing at Evonik.

Evonik; www.evonik.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.030

Gurit secures two-year kit supply contract

Gurit's kitting business unit has reportedly signed a two-year supply contract with a large wind turbine OEMs.

The company will make use of its new kitting production site in Matamoros, Mexico, which opened recently. The contract includes volume agreements for Europe, Asia and Americas and is expected to deliver net sales of CHF 175–200 million over the contract period, dependent on demand.

Gurit; www.gurit.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.031

Arburg wins People's Choice award

Plastics and metal 3D printing company Arburg received the People's Choice award at the Rapid + TCT trade fair for additive manufacturing (AM).

'To us, the Rapid + TCT is one of world's three important trade fairs for additive manufacturing,' said Lukas Pawelczyk, manager of sales at Arburg. 'However, in this field we are still relatively unknown in the USA, contrary to our Allrounder injection molding machines. Therefore, we are particularly proud that our exhibition stand and the two Freeformers impressed the people in Detroit and that we were one of three exhibitors that received the People's Choice Award.'

Lukas Pawelczyk, head of Freeformer sales (right), and Martin Neff, head of plastic freeforming. (Photo courtesy Arburg.)

Arburg; www.arburg.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.032

Nouryon completes microspheres expansion

Nouryon has completed a €20 million project at Sundsvall, Sweden to increase production of its Expancel expandable microspheres.

'Expancel demand is growing fast as we develop new applications to fulfil customer needs,' said Sylvia Winkel Pettersson, director at Nouryon. 'Examples include underbody coatings, weather strips and repair putty for the automotive market, and sealants, floorings and elastomeric cool roof coatings for the construction market.'

Nouryon has completed a €20 million expansion project at Sundsvall, Sweden.

Expancel microspheres are used as a lightweight filler and a blowing agent to make end products lighter and protect against damage or shield against the elements, she added.

Nouryon; www.nouryon.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.033

Composites UK turns 30

Composites UK has celebrated its 30 years anniversary.

Originally the Composites Processing Association (CPA), it became Composites UK in 2007 to include the whole supply chain within the membership, growing over the last decade from 70 members to 370.

The organization celebrated the event by bringing together new and old members and featuring presentations by Lucintel, GKN Aerospace, Polynt, Cecence, High Value Manufacturing Catapult, iMet and Scott Bader.

Composites UK has celebrated its 30 years old anniversary.

Composites UK also announced four new board directors: Jonathan Howard, Dura Composites, Matt Bradney, Prodrive, Adam Black, Technical Fibre Products, and Francis Arthur, TRB Lightweight Structures.

Composites UK;
www.compositesuk.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.034

Gurit appoints new CFO

Gurit has appointed Philippe Wirth as its chief financial officer and member of the executive committee. He will report to Rudolf Hadorn, CEO.

Wirth has a strong business background in finance, business processes and IT, the company says. Before joining Gurit he was Group CFO of Crealogix, a Swiss stock-listed company, and held several senior finance related roles at Mettler-Toledo.

'I am pleased to welcome Philippe Wirth to Gurit as our new CFO,' said Rudolf Hadorn, CEO of Gurit. 'He has broad financial and leadership skills and will be a strong addition to our executive team.'

Gurit;
www.gurit.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.035

Composite lab opened in China

Hexcel, along with composites companies Progen and Future Aerospace, have opened a joint venture laboratory and aerospace materials testing facility in Shanghai, China.

The 1000 m^2 center, called Future Aerospace Hexcel Commercial Composite Testing Limited (FAHCCT) will provide a range of technical services, including support with materials qualification for commercial aircraft programs, the company says. It will also cover mechanical and chemical testing of composite laminate specimens, including fatigue performance and material qualifications.

The lab was awarded AS9100 certification in May 2019 and will work on existing and future aerospace customer specifications, according to Hexcel.

Hexcel;
www.hexcel.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.036

Composites annual report

The Engineering and Physical Sciences Research Council (EPSRC) Future Composites Manufacturing Research Hub says that its 2018/2019 Annual Report has been released.

A copy of the report can be found on the Hub website.

'It's an exciting time and I hope you enjoy reading further about our highlights in composites manufacturing,' said Hub director professor Nick Warrior. 'I would like to take this opportunity to extend my thanks to all those who are driving forward the Hub with dedication, hard work and vision.'

Future Composites Manufacturing Research Hub;
www.cimcomp.ac.uk

0034-3617/https://doi.org/10.1016/j.repl.2019.08.037

Technology

Epoxy with unlimited working life

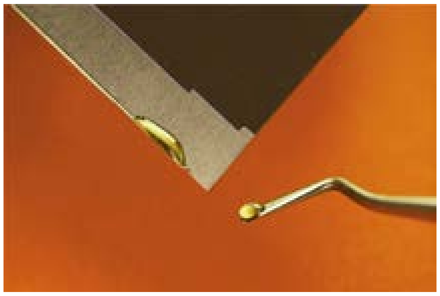
Master Bond says that it has developed an epoxy system with a unlimited working life at room temperature.

Supreme 17HT is a single component, no mix system for bonding and sealing applications, the company says.

The formulation is thermally stable and has a high glass transition temperature of 410°F (210 °C) and retains its bond strength at elevated temperatures, according to Rohit Ramnath, senior product engineer. It is suitable for applications involving repeated exposure to thermal cycling and meets NASA low outgassing specifications asper ASTM E595 testing. 'As a toughened system, it is ideal for bonding dissimilar substrates,' he added.

Supreme 17HT has a lap shear strength of 1900–2100 psi and tensile strength of 7000–8000 psi, with volume resistivity of over 1015 ohm-cm at ambient temperatures and over 1012 ohm-cm at 400°F. It is serviceable from −100°F to +550°F (−73°C to 288°C) and offers a moderate viscosity of 100,000–150,000 cps, Master Bond says.

The epoxy system works at elevated temperatures with cure schedule options including 300°F for 5–6 h or 350°F for 4–5 h. It is available in standard packaging ranging from 1/2 pint to 5 gallon containers as well as packaging including cartridges and syringes.



Supreme 17HT is a single component, no mix system for bonding and sealing applications, the company says.

Master Bond; www.masterbond.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.043

DSM focuses on 3D printing

Chemicals company Royal DSM has partnered with two companies to help develop its 3D printing capabilities. DSM plans to collaborate with Dutch-based composite additive manufacturing (AM) company CEAD to co-develop fused granulate fabrication (FGF) pellet materials and will buy one of CEAD's printers for R&D and commercial purposes.

As previously announced, DSM recently also announced a new partnership with Origin, a San Francisco-based company which focuses on open additive manufacturing.

The company has also launched a 3D printing program called the Trimax Collective which offers its customers a lease of its printers and material.

'DSM will continue to broaden the range of its material solutions to give our customers the largest choice of printing technologies and materials to best suit their applications,' said Hugo da Silva, vice president of DSM Additive Manufacturing. This is why we are building on our SLA, FFF and recently announced powders materials and are entering into the FGF and DLP technologies. These innovative materials take us one step closer to unlocking the full potential of additive manufacturing.'.

DSM: www.dsm.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.044

New 3D printing materials from DuPont

DuPont Transportation & Advanced Polymers has added more materials to the company's range for 3D printing. This includes six new glass fiber-reinforced, carbon fiber-reinforced and unreinforced grades of Zytel polyamide and Hytrel thermoplastic polyester elastomer (TPC-ET) pellets and two new Hytrel filaments. According to the company, the new pelletized materials for pellet extrusion modeling allow the user to switch more easily from prototyping to small-series, pre-series and mass production, while maintaining similar polymer properties. The new pellets and filaments offer a range of hardnesses, fiber reinforcement options and colors.

DuPont says that in 3D printing applications, Zytel pellets and filaments can deliver a balance of strength and stiffness as well as lower shrinkage and warpage for strong, rigid, functional parts.

The glass fiber reinforced grades feature a heat deflection temperature (HDT) greater than 150 °C, improved surface finish and resistance to common solvents and chemicals, while the carbon fiber reinforced grades are lighter and stronger, making them suitable for structural applications in aerospace and automotive.

'As 3D printing capabilities advance beyond traditional prototyping and small-volume production, the industry is looking to scale up and accelerate production while driving down costs,' said Christophe Paulo, strategic marketer, EMEA, DuPont. 'By delivering our products as pellets as well as filaments, DuPont gives customers the flexibility to use the same material across different processes. For instance, they can create prototypes with fused layer modeling and final parts with pellet extrusion modeling – or even injection molding for very high volumes – while maintaining consistent properties.'.

A 35 cm tall branched duct, 3D printed on a pellet printer with DuPont's Hytrel TPC-ET.

Dow DuPont; www.dow-dupont.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.045

CF part for high pressure chromatography

VICI AG International, a Swiss manufacturer of valves and fittings for biomedical instruments, has produced a one-piece fitting for use in liquid chromatography systems made of Victrex's carbon fiber reinforced polyaryletherketone (PAEK) material. According to VICI, the injection molded fitting can withstand pressures of up to 1000 bar (14,500 psi).

The pressures required in liquid chromatography have been rising steadily for over five years, because the particles of the separation materials (usually modified silica gels) now frequently have a grain size of two micrometers or less, the company added. These higher pressures occur between the pump and column in liquid chromatography systems and require the stainless steel connecting capillaries used for the high pressure range to be fastened with appropriate fittings.

Victrex says that, when compared to unreinforced polyether ether ketone (PEEK), using its reinforced material prevents the fitting from breaking apart when it is being tightened, since the carbon fibers are aligned in parallel by the injection process. In the past, this has only been possible in the high-pressure range using conventional two-piece 'nut and ferrule' fittings or complicated one-piece fittings.

'Assisted by Victrex and its material and processing expertise, we have developed and commercialized a new product in this segment to offer users greater flexibility, reusability and above all easier handling compared to steel screw fittings. Also, being manufactured by injection molding, it is favorable in cost terms, too,' explains Hütz. 'We have performed tests showing that, when tightened by hand, the new Victrex HT fittings can be used at 500 bar (7250 psi) and above. When tightened with a tool, they can also be reused at least three times after first use at a test pressure of 950 bar (13,780 psi).'

The fitting designed for high-pressure use. (Photo courtesy VICI.)

Victrex; www.victrex.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.046

Hemp fiber-reinforced plastic wins product of the year

An audience at the 16th EIHA Hemp Conference, which took place in Germany in June, has voted for a hemp fiber reinforced plastic material as one of its hemp products of the year.

BioLite, a polypropylene (PP) reinforced with 30% hemp fibers benefits from the strength of the fibers, making it strong, light and durable, its manufacturer, Trifilon, says. The new material is suitable for lightweight automotive construction and consumer goods and was used in this instance to make a trolley case.

Nova Institute; www.nova-institute.eu

0034-3617/https://doi.org/10.1016/j.repl.2019.08.047

Chem-Trend introduces remote monitoring

Chem-Trend, which makes release agents and other molding products, is expanding the availability of its DilutionIQ System to more customers in China, Europe, and North America, with availability to India, South America, and other parts of Asia in the future.

The system allows for remote monitoring of the release agent process, the company says.

The system consists of a fluid meter panel and a display panel. Users are provided with remote access to the DilutionIQ System through a web application, allowing them to monitor its status, and view the dilution ratio and alarm history. The system stores historical data for every batch mixed. Alarm limits can be set by the userd, and outputs are provided to communicate alarms locally if desired.

'We created the DilutionIQ System to provide our customers with constant, consistent, and connected real-time monitoring of die-lube and release-agent mixing system dilution ratios,' said Bret Miller, executive vice president of sales at Chem-Trend.

Chem-Trend; www.chemtrend.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.048

Improved curing of large sandwich composites

Spanish plastics technology organization AIMPLAS is participating in a project to improve microwave curing of large sandwich-structured parts for aircraft.

The FAMACOM project aims to automate production and reduce energy consumption as well as improve the quality of parts. Currently, large sandwich-structured parts are manually manufactured and autoclave cured, AIMPLAS says. However, a patent developed by one of the project's participating research bodies could allow for more even curing of sandwich-structured parts and overcome the difficulties arising from the thickness and non-uniform nature of these assemblies.

AIMPLAS plans to contribute by focusing on material selection and improvement of the microwave curing process.

AIMPLAS; www.aimplas.net

0034-3617/https://doi.org/10.1016/j.repl.2019.08.049

Graphene composite canopy wins innovation award

A cantilevered canopy made using graphene-based composite materials has won the Innovation Award as part of JEC's Forum Chicago event.

The canopy developed by Graphenano Composites, based in Elche, Spain, and Gazechim Composites Ibérica, is reportedly the world's largest structure manufactured with composites using graphene nanotechnology.

It won the award for its 'contribution of nanotechnology in composites for an avant-garde architectural design', the company said.

The 340 m^2+ structure uses graphene technology in the polymeric matrix to help improve the final composite performance. The graphene reinforcement improves the properties of flexural modulus and tensile strength, while also reducing the overall weight of structures, Graphenano says.

This project also includes other graphene doped elements, such as 275 m^2 of glass reinforced plastic (GRP) profiles in the office's façade and 880 m of profiles for shade slats. In addition, around 3000 m of graphene doped GRP rebars have been used to reinforce the concrete of some areas of the project.

Graphenano; www.graphenano.com

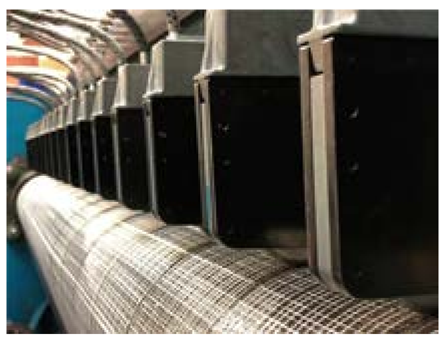
0034-3617/https://doi.org/10.1016/j.repl.2019.08.050

The canopy is reportedly the world's largest structure manufactured with composites using graphene nanotechnology.

Bindatex celebrates 10-year partnership

Bindatex, which offers composite slitting services, is reportedly celebrating 10 years of partnership with a global composites reinforcement manufacturer. The company delivered 50 tonnes of multiaxial fabrics in a wide variety of widths.

Multiaxial, stitched non-crimp fabrics (NCF) are made from numerous layers of carbon or glass fibers are held in place with a polyester thread. The fibers can be in a variety of orientations, for example +45/90/−45 degrees. One of the advantages of using multiaxial composites over woven materials is that they can increase efficiency in the lamination process as multiple layers of thicker fabrics can be laid up more quickly, Bindatex says.



Bindatex's slit multiaxial tapes are reportedly suitable for aerospace, marine and automotive industries.

However, the construction of this type of material presents many challenges during the slitting process, as it is important to ensure a clean cut and accurate slit edge without compromising the fiber orientation and the handling characteristics of the materials.

Bindatex; www.bindatex.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.051

New range of weaving machines

UK based 3D weaving machine manufacturer, Optima 3D, has launched a new range of weaving machines for 3D composite engineering.

The Optima Series 500 range reportedly offers improved features compared to conventional products due to its digital control systems, which allow rapid parameter and sequence changes coupled with a patent pending shuttle system.

The machines can produce woven net shapes, billets and para beams for composite applications, the company says, for a range of engineering sectors including aerospace, military, bio-medical and automotive. They are suitable for both production and R&D purposes.

Optima 3D; www.optima3d.co.uk

0034-3617/https://doi.org/10.1016/j.repl.2019.08.052

Plastics recycling method is alternative to mechanical

VTT Technical Research Centre of Finland says that it is researching chemical recycling of plastics based on pyrolysis, which can turn nearly all plastics and their mixtures into oil.

According to the organization, while mechanical recycling suits most plastic bottles, bags and wraps, 40–60% of separately collected plastic waste in Finland does not qualify for this type of recycling and ends up incinerated.

'By chemical recycling, however, plastics and their mixtures can be broken down into separate raw materials, whose quality is equal to that of respective virgin materials,' said Anja Oasmaa, senior principal scientist at VTT.

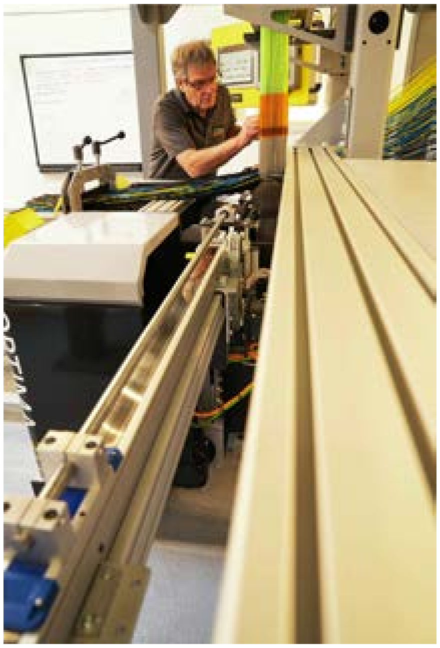
According to VTT, chemical recycling offers an ecologically sound alternative to incineration and possibly to mechanical recycling as well. Current legislation in

Finland and the EU does not recognise chemical recycling of plastics as being equal to mechanical recycling.

The pyrolysis involves heating long polymer chains of plastics and their mixtures in the absence of oxygen, thus chopping them into shorter chains and in part even to monomers. The resulting pyrolysis wax or oil could be processed with traditional methods at oil refineries, VTT says.

'Pyrolysis oil can be distilled into separate monomers, diesel and other fractions, some of which can be used directly as fuels and some as raw material for plastics and other chemicals,' added Oasmaa.

VTT says that it is also looking into the recycling of polystyrene, the removal of hazardous compounds from plastic waste and the production of diesel fuels from plastic waste to be used in power generation and marine transport.



The machines can produce woven net shapes, billets and para beams for composite applications.

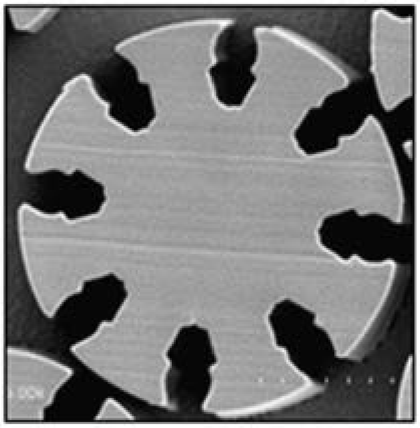
VTT;www.vttresearch.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.053

Water repellent textile

Toray Industries has developed a new nylon textile that it says has high water repellency. The textile, made using the company's Nanodesign composite spinning technology, has microscopic slits running lengthwise on the yarn which can be filled wth water repelling below the outside diameter of the yarn, making the treatment more abrasion-resistant.

Despite the slits, the textile has the strength and abrasion-resistance of other yarns and is processed the same way, Toray says. Fluorine-based water repellents used in the past do not easily decompose naturally because of its stable chemical structure.



Cross section of Toray's nylon textile

Toray plans to market the textile in autumn 2020.

Toray; www.toray.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.054

Advances in carbon fiber 3D printing

Additive manufacturing company Impossible Objects has formed a partnership with BASF to widen the range of applications for its composite based additive manufacturing process (CBAM).

The company has developed a new 3D printing machine, called the CBAM-2, which it says can deliver more complex parts on an industrial scale, speeding up the additive manufacturing process as much as 10 times combining polymers with long fiber carbon and glass fiber sheets.

According to Impossible Objects, the system can print 3D parts from composites that are not available through other 3D printing methods. Printed sheets can now reach up to 12 inches × 12 inches in size and the CBAM-2 features three added cameras, helping improve quality control.

The printers can now use BASF's Ultrasint polyamide 6 (PA6) powder, allowing customers to 3D print carbon fiber reinforced PA6 composite parts for the first time. According to the company, carbon fiber/PA6 composites offer better strength and temperature performance at a lower cost than PA12 and are up to four times stronger than conventional fused deposition modeling (FDM) parts and twice as strong as multi jet fusion (MJF) parts made with PA12.

Impossible Objects; www.impossible-objects.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.055

AMUT Group supplies membrane lines

Italy-based AMUT Group says that it has supplied two extrusion lines producing polyvinyl chloride (PVC) and thermoplastic olefin (TPO) waterproofing membranes in to China.

'We are becoming the largest supplier of waterproofing materials around China reaching a productivity capacity of 10,000,000 m^2/year of waterproofing membranes in polymer and 20,000,000 m^2/year of waterproofing membrane in bitumen, said Qian Lindi, chairman of Jiangsu Canlon Building Materials Co Ltd, which commissioned the lines. 'With these two new extrusion lines supplied by AMUT Group as turnkey project, we will rise our production up to 25,000,000 m^2/year of waterproofing membrane in polymer.'

AMUT Group says that it has supplied two extrusion lines for the production of waterproofing membranes.

The PVC membranes have a three-layer configuration and can incorporate different reinforcements such as polyethersulfone (PES) mat, glass fiber net and polyester fleece. The membrane rolls have a net width of 2000 mm and a thickness up to 3000 (μ). The output is 2.200 Kg/h.

The TPO membrane has a three -layer configuration and can have different reinforcement such as polyester grid or PES-non-woven textile. The membranes rolls have a net width of 2000 mm and a thickness up to 2000 (μ). The output is 2.000 Kg/h.

AMUT Group;
www.amutgroup.com

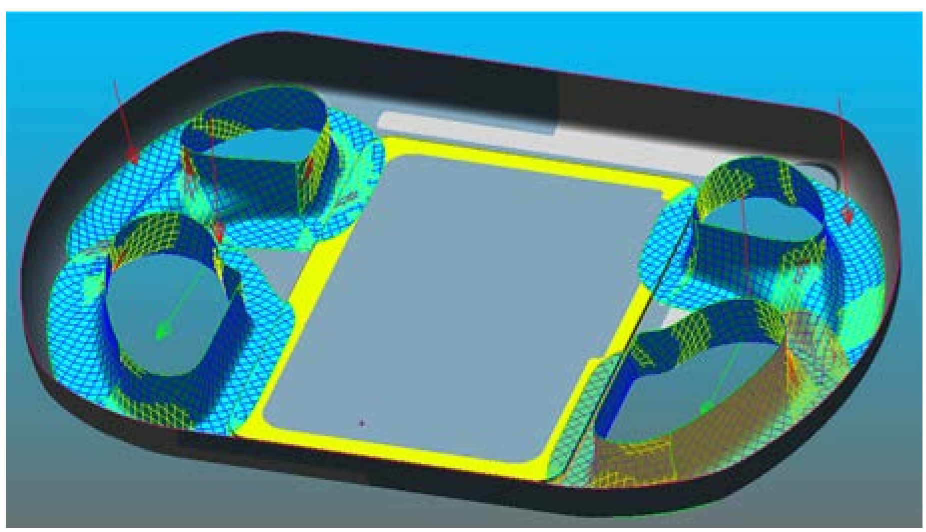
0034-3617/https://doi.org/10.1016/j.repl.2019.08.056

New version of Laminate Tools software

Anaglyph Ltd says that it has released version 4.9 of its Laminate Tools composite structural design software.

The new features include implemented tensor plots for principal element forces/moments, additonal ply pools and element set pools, allowed basic geometric feature creation and enabled import of additional FEA result entities.

Laminate Tools is a stand-alone Windows application that addresses the geometry import-design-analysis-check-manufacture process of composites structural design, the company says. It links various disciplines, communicates data between those involved in the process, and can interface with most CAD and FEA applications. It is reportedly suitable for automotive, aerospace, marine, energy and leisure applications.



The software is suitable for automotive, aerospace, marine, energy and leisure applications.

Anaglyph Ltd;
www.anaglyph.co.uk

0034-3617/https://doi.org/10.1016/j.repl.2019.08.057

Partnership focuses on graphene filled thermoplastics

XG Sciences, which works with graphene nanoplatelets, says that that it has entered into a memorandum of understanding (MoU) to research graphene filled composites for the Chinese market.

The company had also opened the Graphene Applications Development Center (GADC), a joint venture company between Sinochem Plastics Co Ltd and Yuyao PGS New Material Technology Co Ltd in in Yuyao City, China. The parties recently partnered to develop graphene enhanced anti-corrosion coatings for industrial and marine applications.

Under the new MoU, graphene-filled thermoplastic composites will be developed by GADC using XG's xGnP graphene nanoplatelets. The companies plan to use a range of thermoplastic materials for markets including automotive, industrial, and consumer items such clothing. Products resulting from the collaboration will be manufactured and sold in China through Sinochem and PGS.

XG Sciences; www.xgsciences.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.058

New bio resin for RTM processing

Sicomin has launched a new bio-based epoxy resin designed for high pressure resin transfer molding (RTM) processing.

The company says that SR GreenPoxy 28, the sixth product to be added to the GreenPoxy range, can be used as a replacement for petroleum-based material.

The resin is a fast cycle, low toxicity, third generation bio-based formulation and is suitable for making structural parts and carbon fiber components. It can be cured using a two-minute cure cycle at 140 °C, producing an onset Tg of 147 °C, as well as improvwed mechanical properties under both dry and hot/wet test conditions.

Sicomin; www.sicomin.com

0034-3617/https://doi.org/10.1016/j.repl.2019.08.059

FEATURE

Improving the bonding and longevity of adhesives and resins

Django Mathijsen

Rivets, bolts and fasteners... for many manufacturers and mechanical engineers these are still the most tangible ways to join parts together. Seeing a nice row of bolts is reassuring and confidence inspiring. Adhesives are often seen as a black art and met with skepticism. Although adhesive bonds can be stronger than the materials they bond together, they are still often backed up with so-called "chicken rivets". We talk to the director of the Adhesion Institute in the Netherlands to get an insight into adhesive systems and see what the future might hold.

"We are mainly looking at ways of improving the bond between adhesives and plastics with physical methods like for example ultraviolet light in combination with ozone gas," says Dr. Hans Poulis, assistant professor at the Delft University of Technology and director of the Adhesion institute (http://www.adhesioninstitute.com/). "That works really well because it cleans the surface and when the last pollutants have disappeared, it oxidizes the surface a little bit, which results in a much higher surface energy and improved wetting of the surface when the adhesives are applied. That way you obtain a much better bond than with other methods. It not only results in a great improvement initially, but also in more durability."

Cleaning before bonding is crucial

Pollutants often consist of long polymer chains: fatty deposits. They are usually removed using solvents. But solvents can be highly flammable and pose a health hazard. So, they require extensive air extraction systems. "You still need some ventilation the way we do it," Poulis says. "But it is a closed system. We shine an ultraviolet lamp onto the surface, contactlessly cleaning it."

Conventional cleaning methods do not take away all pollutants. A few minutes of exposure to an ultraviolet lamp in combination with ozone gas, however, will clean plastic as well as metal surfaces thoroughly. The ultraviolet light breaks down organic material, cutting long polymer chains into smaller bits. That results in radicals on the ends. At the same time the ultraviolet rays produce ozone in the ambient air which in turn oxidizes those radicals. "Ozone is very unstable and reactive," Poulis explains. "So, you generate a kind of plasma close to the surface which cleans and oxidizes it." The fatty deposits are in effect oxidized away.

"We often perform some rough pre-cleaning: first, taking away the biggest amount of surface pollutants with a relatively harmless, broad spectrum cleaning agent like PFQD," Poulis adds. "Subsequently, we further improve the surface cleanliness with the ultraviolet lamp." This combination turned out to be an improvement compared to for example cleaning a surface with M.E.K. (Methyl Ethyl Ketone). When the surfaces were then bonded together, it resulted in improved adhesion and durability of the bond.

"The technique offers high repeatability and extremely good results, at least comparable to plasma cleaning, and often even much better," Poulis says. The ultraviolet lamps used are basically normal fluorescent tubes but without its white phosphor coating on the inside (Figure 1). In regular fluorescent tubes this coating converts the bluish and ultraviolet light spectrum emitted by the mercury vapor inside to a white or yellow spectrum of visible light. So the technique is cheap and very environmentally friendly. "Providing of course you bring the ultraviolet tubes in for recycling at the end of their life," Poulis adds.

Proven but rarely applied

So, the ultraviolet cleaning method offers clear advantages. And it is not really a new technique: it has been proven to work in many applications as Poulis explains: "I have already been using it since my dissertation in 1993. There it was used to bond stainless steel in electro-pneumatically controlled hands for children who were missing their forearms. The moving parts that had to be joined together were so small that welding or brazing was

0034-3617/ https://doi.org/10.1016/j.repl.2018.10.005

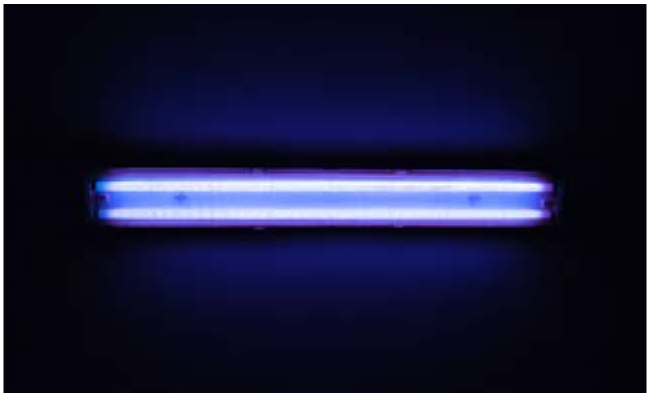


FIGURE 1

Ultraviolet lamps are mercury-vapor gas-discharge lamps, just like fluorescent lamps, but without the fluorescent coating (Photo: Shutterstock/AstridSinai).

not an option: that would cause too much warping. So they were adhesively bonded together. But stainless steel is very difficult to clean well repeatably. However, ultraviolet light turned out to work very well. We have also used it to great effect on automotive steel and many plastics, like ABS, PE, PP and HDPE. Those plastics are often difficult to bond. We are currently using ultraviolet cleaning in a European project for bonding carbon fiber reinforced plastics to titanium in aircraft wings with astonishingly good results. In testing it turns out that bonds that were pre-treated with ultraviolet light and ozone never break. It is the composite material itself that fails due to intra laminar failure."

Although Poulis has used the technique on many projects, it is seldom applied in industry, although it has found extensive use in treating the lenses of CD-players. "Those lenses are waiting on a sort of bridge in the assembly line before the adhesive is applied," Poulis explains. "That is when they are exposed to ultraviolet light to get them nice and clean. The integrated circuit industry also uses the technique to clean the wafers the chips are made of" (Figure 2).

FIGURE 2

Cleaning with ultraviolet light and ozone is performed on chip-wafers and on the lenses of CD-players (Photo: Shutterstock/Rainer Plendl).

A reason why the ultraviolet cleaning method has not taken off on a large scale yet may be because it requires an exposure time in the order of five minutes (or half of that, when a higher ozone concentration is used). That can be a problem in large series manufacture where you want to churn out products as fast as possible. The technique is ideal however if you can incorporate a five-minute buffer in your assembly line.

Laser pre-treatment

The second disadvantage of the ultraviolet cleaning method is that the lamps, just like normal fluorescent tubes, come in a bar-shape as standard, which tends to limit the parts you can clean to mostly flat surfaces. If you want to treat more intricate, bi-curved shapes and surfaces, you have to bend the fluorescent lamps and mount them in such a way that they follow the shape you want to clean. The distance from the source of the ultraviolet light to the surface to be treated has to remain about constant. That takes a large investment, rendering the method rather expensive if you are only making one-offs or small series of products.

"I do see related systems being used now," Poulis says. "Laser pre-treatment for example. But that has a different spectrum and is of course much more expensive."

Of course, the resins used in the composites industry are a form of adhesive as well. So theoretically it could be advantageous to clean the fibers using ultraviolet light before bonding them to the resin. "We have often used ultraviolet cleaning on glass," Poulis explains. "That results in a much better spread of the adhesive and a stronger and more durable bond." But fibers often come with a silane-based coating, a "sizing", to improve the bond. And the effects of the ultraviolet light on this coating are not yet fully understood.

To last for centuries

Another project the Adhesion Institute is working on is to develop exceptionally stable adhesives, designed to last not just decades... but several centuries! "In 2015 we got a research project into flaking paint layers approved by the Netherlands Organization for Scientific Research in corporation with the Rijksmuseum and the Stedelijk Museum Amsterdam," Poulis explains.

If you look at old paintings, you can often see the paint crackling (Figure 3). If you take a closer look, the paint flakes are usually also letting go of its base, which is typically canvas, wooden panels or glass. Especially during transport, vibrations can cause those flakes to fall off (Figure 4). Canvas is especially prone to vibration resonances in transport. If that happens, you lose bits of the original painting.

"You can retouch the flakes of course, but sticking the flakes back on is preferable," Poulis says. "That is now often being done using synthetic adhesives. Organic adhesives were used, but they are not very stable: they tend to age and discolor. You see that with epoxies as well: they often turn yellow, especially if they are used outside. It happens inside as well, but more slowly. At the same time its mechanical behavior changes."

Many restorers have to use adhesives that are not really suitable for this application since hardly any adhesives have been

FIGURE 3

The paint is often crackling in old paintings (Photo: Django Mathijsen).

FIGURE 4

If you take a closer look you can see that the flakes of crackling paint are usually letting go as well. These loose flakes are prone to falling off, especially during transport of the painting (Photo: Django Mathijsen).

especially developed for the restoration world. Of the ones that are used, the ingredients are often changed without notice. This might negatively influence the durability aspects of the consolidated art, which is an application that requires much greater durability than the regular applications of these adhesives. The market for consolidants is too small for separate commercial developments, since restoring a painting will typically only require a few droplets of glue. "We now have funding to do research to develop extremely stable adhesives that keep their mechanical characteristics for a very long time," Poulis says. "Then it is not only important to know their initial behavior but also how they behave in time. That way we can predict what such an adhesive system will look like after for example 200 years and have a very good idea of how it will behave mechanically and chemically. Is it going to become brittle, weaker or yellow?"

Aggressive aging

The adhesive system is being developed by mixing basic components and then performing tests to see how the combination ages (Figure 5). Because it is not viable to run a true two-century test on an adhesive bond, the aging has to be sped up. But the results of these tests turn out to be quite accurate.

"The faster you start aging, the more aggressive you have to make the environment for the adhesive system and the larger the uncertainty in your time estimate will be," Poulis explains. "But some adhesive systems have been in use in the aircraft industry for forty or fifty years. We have data of that here at the faculty of aerospace engineering. So, you can compare the initial, sped-up aging tests to the actual aging of a product that has been flying for half a century. Fokker used to do aging tests for bonded aluminum with 0 weeks, 3 weeks, 6 weeks and 10 weeks of exposure in a salt spraying cabinet. Those predictions turned out to match the actual lifespan quite well."

Also, the variables temperature and humidity can pretty much be replaced with constants where paintings are concerned, since the environment is kept quite constant in museums. The most aggressive variable however is light. So, a Xenon-test is performed where ten weeks of exposure produces about the same aging of the polymer as 200 years in a museum. "We use those tests to compare the aging of different materials we have designed and to compare them to commercially available materials," Poulis says. "We can also replace the filter in the exposure box with an outside filter. Exposure to the elements outside is much more complex because there are more factors at play, like rain, condensation, moisture penetration, frost, ultraviolet light

FIGURE 5

Mock-up of flaking paint at the Adhesives Institute to test new adhesives on (Photo: Adhesion Institute).

and varying temperatures and humidities. There are calculational methods and models for that."

Poulis explains why commercially available adhesives are avoided: "With commercially available adhesives you never really know their composition. Oftentimes they consist of ten or twenty components. And five years down the line, the adhesive might not be on the market anymore or its composition has been (slightly) changed. We use basic components like acrylates, low or high molecular resins and often some light stabilizers. We always start with a base material we know to be quite stable. We have limited ourselves to a small, select group of materials because our project time is limited." The institute is cooperating with Dutch adhesives company Permacol to market the new adhesive systems that will come out of this research.

Glass adhesives

The adhesives are being developed for different types of paintings, like oil-based and gouache. But the interest of anyone in the reinforced plastics industry should especially be peaked by the adhesives developed to restore reverse glass paintings (Figure 6). "Those are paintings on the back of glass," Poulis explains. "They can look very beautiful but a few hundred years down the line the paint can start to let go and then they cannot be displayed anymore. If you want to restore them, you need an adhesive that hardly has any discoloration."

FIGURE 6

A craftsman performing reverse glass painting. When these paintings age and start to crack, the flakes have to be glued back with an adhesive that will stay perfectly translucent without any yellowing (Photo: Zoran Karapancev/Shutterstock).

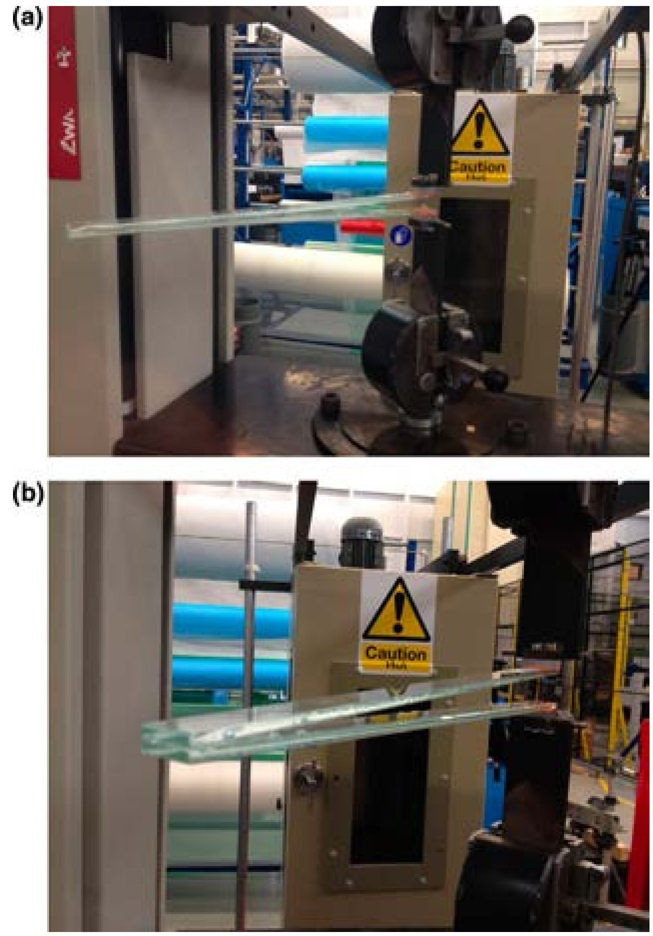


FIGURE 7

a and b: Double cantilever rig for mechanical testing of adhesives (Photos: Adhesion Institute).

If you would use a normal epoxy resin for sticking back those paint flakes onto a reverse glass painting, the result might look fine right after restoration. But within a few decades the epoxy will turn yellow, in effect ruining the painting, often rendering it non-restorable.

Since glass is used in fibers to reinforce plastics and the resins used in composites are basically a form of adhesive as well, the results of this research project might also spark insights into developing more durable resin systems.

"In our lab, the bond of the adhesive to the glass is now so good that in testing it is the glass that breaks, even with a twenty percent dilution," Poulis says (Figure 7).

More durable resins

Imagine reinforced plastics products that could last two centuries. Of course, that should rule out consumer electronics which these days tend to reach the end of their life already in three years. And mass-produced cars tend to be scrapped after ten or twenty years. But there are obvious applications in products which are exposed to the elements and are required to last

FIGURE 8

Imagine if we could make plastics last for centuries or even millennia with hardly any aging. Then we could build a landmark monument to reinforced plastics as a testament of the achievements of our time for generations to come. Who is going to take up that challenge? (Photo: Shutterstock/Repina Valeriya).

FIGURE 9

Although the rare 1949 Glasspar G2 was arguably the first production car with a glass fiber body, the public at large was introduced to glass fiber car bodies over half a century ago with this 1953 Chevrolet Corvette (Photo: Shutterstock/Steve Lagreca).

FIGURE 10

It usually takes a lot of sanding and re-laminating to restore a glass fiber body like on this 1962 Lotus Elan once it has faced the elements for more than half a century (Photo: Shutterstock/Martin Charles Hatch).

FIGURE 11

Will iconic carbon fiber bodied cars of today like this BMW i8 still be around in half a century (Photo: Shutterstock/Patrick Poendl)?

FIGURE 12

A carbon fiber reinforced polymer guitar is another object that you would like to build out of materials that can last for centuries (Photo: Shutterstock/Jose Luis Carrascosa).

in the order of a century or are very critical and should never experience a failure.

Now that fiber reinforced polymers are more and more being used in construction, like bridges for example, maybe it is time to start thinking about materials that can last for centuries so that one day a landmark made of reinforced plastics can enter the ranks of the Chinese wall and the pyramids (Figure 8).

And certain cars, especially sportscars like the 1953 Chevrolet Corvette and 1962 Lotus Elan, become classics and should be preserved as cultural icons in their own right (Figures 9 and 10). People would like to be able to still experience and enjoy them in centuries to come. Both the Elan and Corvette are early examples of cars with glass fiber reinforced polymer bodies. Many of them are still on the road, but that is mainly because the countless cracks and microfractures their bodies have accrued over time have been lovingly sanded back and repaired with fresh fibers and resins.

That makes you wonder what the future will hold for the many carbon fiber reinforced polymer bodied cars on the market today. Will a BMW i8 for example still be on the road in half a century (Figure 11)? And what about a carbon fiber polymer musical instrument (Figure 12)? "You see a lot of materials becoming brittle as they are exposed to the conditions outside," Poulis says. "It is basically a form of weathering of the polymer."

Sustainability

Many industries are now mainly geared to manufacturing products with relatively short lifespans that can be easily recycled. But recycling is not the be-all, end-all of sustainability. Recycling typically costs a lot of energy. And in all recycling processes, some material is usually lost. So, especially in niche products, materials that could last for centuries would definitely be a boon.

"Another advantage of our adhesive mixes is that they are no complex mixtures of many different components," Poulis adds. "They only consist of a few components and they are soluble in solvents like toluene or ethanol. So, separating those components for recycling at the end of their life can be realized more easily."

If you are interested in improved adhesive bonds or in research to lengthen the lifespan of adhesives and resins, do not hesitate to send Hans Poulis (J.A.Poulis@tudelft.nl) an e-mail.

FEATURE

Update on "From earth to heaven": How professional 3D Printing and Windform® GT material helped in the construction of drone and medical devices

Veronica Negrelli, Press Office Manager

Tundra-M drone

Windform® 3D Printing materials, which were originally developed for the motorsports industry, are now finding a diverse range of uses outside the race track, e.g. UAS field.

The object of this chapter illustrates the manufacture of an unmanned aerial system using Laser Sintering technology and Windform® composite materials (Photo A).

The project has involved two companies: CRP Technology and Hexadrone. The aim is the construction of Hexadrone's first fully modular and easy-to-use drone for industrial and multi-purpose tasks, made for extreme weather conditions thanks to rugged, waterproof design.

The rapidly swappable arms and three quick release attachments make the Tundra-M extremely flexible to meet the needs of any profession, while making operational conditions easier to maintain.

The Tundra-M is conceived around a multifunction perspective. The Tundra-M can rely on its four quick connect arms as well as its three accessory connections to turn into a formidably effective and very pliable work tool. This makes the Tundra-M suitable for plenty of different flight scenarios as well as plenty of professional uses.

The body as well as the main parts have been conceived with the composite polyamide based material carbon filled Windform® SP and Windform® XT 2.0. Those two materials are shaped into pieces using the selective laser sintering 3D printing technology.

The four arms supporting the body frame of the Tundra were 3D printed using Windform® XT 2.0 composite material.

The rest of the components were developed with the Windform® SP composite material.

The collaboration

Understanding the limitations with traditional manufacturing technologies, the opportunity to develop a unique drone based on the use of Additive Manufacturing (AM) technologies was identified. Additive Manufacturing technologies in UAS applications has presented both opportunity and challenges to engineers in the field. The ability to produce parts and components using Additive Manufacturing technologies hold promise in both metals and plastics, whereas, traditional Subtractive Manufacturing technologies can be restrictive in design development and material selection.

Hexadrone has requested CRP to devise the functional prototype of the Tundra-M, Hexadrone's very first mass-produced drone.

Hexadrone CEO Alexandre Labesse commented, "We have engineered our drone by means of a cautious, multifaceted, and collaborative based approach with the involvement of broad-based stakeholders.

In the course of two years of consulting, research and development we have gathered all the advice and customers' testimonials useful to its design and which finally helped us in the process of devising an ideal UAV solution".

Additive Manufacturing technology is often faster than designing and producing a tool for traditional manufacturing technologies. Furthermore, 3D printing has given engineers more flexibility in the timeline to make design improvements and being able to think outside of limitations caused by traditional tooling. This choice made it possible to substantially reduce the costs and has been very convenient in terms of timing when compared to traditional production methods. The unique properties of AM Windform® XT 2.0 and Windform® SP composite materials have allowed system optimization that successfully withstands the design requirements due to space limitations and the extreme conditions during flights.

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PHOTO. A

Hexadrone moved to SLS technology in collaboration with CRP Technology in order to accelerate iteration generation, improve manufacturing time and facilitate series production.

"The Windform® selective laser sintering technology – Alexandre Labesse added - allowed us to easily prototype key components of our product, to outcompete the plastic injection molding process in terms of deadlines, cost, and to test our prototype in real life conditions with almost the same mechanical characteristic".

The project we have designed with these two materials, the Windform® SP and the Windform® XT 2.0 from CRP Technology, lies in the conception of different frame parts, junction parts, a quick release patented system as well as the components forming our patented carbon-made arm system.

This 3D printing time/cost saving technology helped us a lot and now allows us to calmly approach the mass production phase.

The requirements were fast iteration process, best ratio between structural strength and weight, acceptable consistent result and opportunity to combine multiple functionalities from one unique part.

CRP Technology provided fast response time to new requirements, very good cooperation with Hexadrone and CAD designer and best output quality with unique proprietary process.

Alexandre Labesse stated, "Regarding the most innovative aspect of Laser Sintering technology with Windform® materials, lies in the possibility to prototype with all the pros of the plastic injection process without the cons this method entails in terms of cost and deadlines. Furthermore, Windform® provides us with a close enough material in terms of properties (eg, density, colour, tensile strength, modulus, elongation at break etc)".

Evaluation criteria/critical problems overcome through SLS technology and Windform materials

The main stress/efforts involved in the application were:

- Compressive stress
- Tensile stress
- Vibrations
- Traction stress

The critical problem of this application resides in a lack of precision resulting in a scale gain. This gain lies between 0.15 and 0.20 millimeters. If not anticipated, this gain can compromise the assembling of the different parts as trying to fit them together.

Tundra-M drone: Parts in Windform composite materials

The most interesting parts that have been made using the Windform® SP and the Windform® XT 2.0 are (Photo B):

- The body frame which is composed of the main frame plus a removable top lid. This component contains the brain of the Tundra-M (the main circuit boards as well as the cooling system).

PHOTO. B

CEO Hexadrone Alexandre Labesse, "To devise this component, we were in need of a water-resistant, durable and sturdy material. Moreover, this sturdy frame comes with an emergency parachute, four removable and scalable arms, two batteries as well as three easily interfaceable accessories".

The Windform® composite material used for the body frame is Windform® SP due to its mechanical and thermal properties

- The arms which are composed of motor supports plus the removable arms plus its interlock base which allows the user to easily tighten the four arms with the support of a patented "tension ring": This stiff system allows the user to connect and disconnect the interchangeable arms on a discretionary basis (Photos C and D).

CEO Hexadrone Alexandre Labesse, "Our patented technology offers a reliable and sturdy connection while being a waterproof solution in case of inclemency. This interlocking connection is also able to handle the stress due to leverage forces. Those leverage forces are primarily generated through the components at the end applying a constant force through masses".

The Windform® composite material used for the arms is Windform® XT 2.0

SLS technique and Windform® composite materials: The pros by Hexadrone

PHOTO. C

Tundra 3D printed body frame in Windform® SP.

PHOTO. D

Tundra 3D printed body frame in Windform® SP.

Windform® SP.

Class of material:

Composite polyamide based material carbon filled.

Technology:

Selective Laser Sintering / Additive Manufacturing.

Main characteristics:

- Top mechanical features.
- Excellent resistance to damage, vibration and deformation.
- Excellent thermal properties and resistance to high temperatures.
- Waterproof material.
- Material of choice for functional applications.

The performance of this application as to what it allowed Hexadrone to create in terms of mechanical parts was essential due to its intrinsic material qualities. Therefore, the quality of this component had a great incidence over a number of key factors (Photos E and F):

- Flight tests, which, thanks to the Windform® SP and Windform® XT 2.0 are run in real-world service test conditions. This application allowed the completion of successful flight tests for the Tundra-M.
- The flexibility of the Windform® material and its compatibility with many different applications makes it an ideal candidate for demanding applications.

Windform® XT 2.0.

Class of material:

Composite polyamide based material carbon filled.

Technology:

Selective Laser Sintering / Additive Manufacturing.

Main characteristics:

- Top level material.
- High stiffness and excellent strength and reduced weight.
- Material of choice for functional applications such as components for small production and pre-series parts.

PHOTO. E

Tundra 3D printed arms in Windform® XT 2.0.

PHOTO. F

Tundra 3D printed arms in Windform® XT 2.0.

Furthermore, thanks to Windform® SP and Windform® XT 2.0, Hexadrone benefited from the plastic-like materials' properties without the common drawbacks. The drawbacks of plastic injection molding, mainly its cost and its time consumption, make it unfit for prototyping.

What prompted Hexadrone to focus their intention on the Windform® technology from CRP was:

- The possibility to have access to printed parts within very short deadlines at a very cost-effective price.
- Windform® family of composite materials can compete with the injected plastic in terms of tensile strength, stiffness, tensile modulus, elongation at break, shear strength, flexural strength, flexural modulus, traction stress vibrations, resistivity as well as density and its low moisture absorption rate.
- The price which makes Windform® technology a highly profitable solution for prototyping purposes.
- The fact this method produces zero undercut as well as zero flaws which is also a good point for prototyping jobs. (Flaws are often noticeable on industrial pieces which were produced using the plastic injection method).
- Windform® material density which induces a low mass making Windform an ideal component for the prototyping of UAVs and the completion of their flying tests.

This allowed Hexadrone engineer to have an acute in-flight first impression as to the behavioral characteristics of the different parts processed with Windform® carbon fiber reinforced composite materials.

SLS technique and Windform® composite materials: the advantages by Hexadrone

The advantages obtained by Hexadrone with the technology and Windform® family of composite materials are:

- Windform density, which makes it lightweight material suitable for UAV prototyping phases and testing phases.
- The price, which makes it a smarter solution than plastic injection if you are to run through iterations. Plastic injection is considered financially too risky if you were to notice design flaws (In case of design flaws, the mold become obsolete and then you can't make it profitable for the company).
- The neutral color and texture suitable for prototypes.
- The thermal properties suitable for UAV prototypes.
- The mechanical properties making it a very competitive material similar to injected plastic, in terms of the various stress an UAV has to face while flying.
- The electrical properties suitable for the prototyping of functional parts which are to be mounted in an electrical environment.
- The moisture resistance thanks to its low absorption rate suitable for the Tundra-M, an UAV vowed to extreme weather.

SLS technique and Windform® composite materials: The tests carried out by Hexadrone

The tests Hexadrone carried out on the prototype they designed using Windform® reside in:

PHOTO. G

Tundra 3D printed functional prototype at CES 2018.

- The assembly/disassembly tests of the different parts to road test their structure as well as the fatigue resistance of this new material.
- Landing tests, folding and unfolding the landing foot structure of the Tundra-M drone whose different structures were made in Windform® SP and which support the full weight of the Tundra-M. On top of the weight of the device those small parts also have to handle the stresses due to the folding/unfolding of the landing system.
- Flight tests, to determine whether the mounted parts can handle the different strains encountered throughout the many different flight scenarios (Photo G).

About Windform® composite materials (carbon fiber reinforced XT 2.0 and SP)

Windform® XT 2.0 and Windform® SP are the LS polyamide-based carbon fiber reinforced Windform® materials within Windform® family of high-performance composite materials.

Windform® XT 2.0 is the ground breaking carbon fiber reinforced composite 3D printing material known for its mechanical properties. It is particularly suitable in demanding applications such as motorsports, aerospace, and UAV sectors.

Windform® XT 2.0 is an innovative material which replaces the previous formula of Windform® XT in the Windform® family of materials. Windform® XT 2.0 features improvements in mechanical properties including +8% increase in tensile strength, +22% in tensile modulus, and a +46% increase in elongation at break. The material allows for the creation of accurate, reliable, and durable prototypes and is perfect for functional applications.

Windform® SP has excellent mechanical properties similar to Windform® XT 2.0, with the addition of increased resistance to shock, vibrations, and deformation. The material also shows increases in impact strength and elongation at break, as well as excellent thermal properties and resistance to high temperatures.

Windform® SP has waterproof properties, and it is resistant to absorption of liquids and moisture.

It is suitable for dyno testing and on track testing, for applications requiring resistance to impact, vibration, deformation, and high temperatures.

Windform® SP is the material of choice for functional applications in Motorsports, Automotive (under the hood components such as intake manifolds), Aerospace and UAVs.

FEATURE

CRP Group's technology supporting the first Italian high performance electric motorcycle: Development and construction of the Energica Ego motor housing and dashboard

Veronica Negrelli

In Modena, homeland of supercars and motor valley of Italy, the first high-performance full electric motorcycles 'Ego' was born in Energica Motor Company S.p.A. Ego was rigorously developed using F1 technologies and the Windform® family of high performance composite materials. Energica was created and engineered through the CRP Group, whose decades-long activity in the field of High Precision CNC machining and professional 3D printing, along with Windform® composite materials for Additive Manufacturing, allowed the creation of innovative and avant-garde solutions that have made Energica a unique model throughout the world.

The use of Laser Sintering technology and Windform® composite materials enabled Energica to be on the market quickly, accelerating the prototyping and product development phase.

The Energica project stems from the entrepreneurial vision of the Cevolini family, owners of the CRP Group, after the CRP Racing experience in parallel with eCRP back in 2009.

The CRP Group was fundamental for the industrial development of Energica since the very first prototypes, which contain parts made with Selective Laser Sintering technology and Windform® carbon or glass fiber filled composite materials. The materials were engineered by the RD department of CRP Technology, the CRP Group's company that has been dealing with professional 3D printing for over 20 years.

Energica has also benefited from the experience gained by the CRP Group in over 45 years of activity as a supplier of innovative and cutting-edge technological solutions alongside the major F1, Moto GP, Rally Raid and ALMS teams. The Group has always provided these teams with a high level of support during the entire development phases of the projects, from the early stages of design and development to the construction process, with consequent recognition of an innovative approach in the use of new materials and technologies.

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1. Application case no. 1: the motor housing

The object of this chapter is the creation of the Energica Ego motorcycle motor housing. The motor housing is an important component of electric motorcycles, with highly complex features. Right from the very start, Energica engineers and CRP Group staff worked together to redesign the component, in order to accommodate the rotor, stator, and the speed reducer. The propulsion unit to be supported is so flexible and compact, that the Energica motor housing can be adapted to any vehicle. The Energica Ego reducer is composed by straight-cut gear train that adds strength while providing simplicity of design and a pleasing sound. The structure holds the shaft and pinion and final drive to the wheel with a standard, tried-and-true motorcycle chain.

For the redesign of the motor housing, Energica and CRP teams had to consider different requirements, namely:

- Lightness (since the electric motor was heavy, the housing had to be light)
- High resistance (because the motor generates a high torque)
- Correct sizing of the gears and appropriate choice of materials/ heat treatments.

The partial structural support of the frame is provided by the motor housing itself.

1.1. First step: creation of the 3D printed functional prototype

CRP Technology, the CRP Group's leader in the field of professional 3D printing with Windform® composite materials, handled the construction of a functional prototype (Photos 1 and 2).

The prototype was manufactured via SLS technology in Windform® LX 2.0, composite polyamide based material reinforced with a new generation glass fiber now replaced by Windform® LX 3.0. The part allowed the technicians to validate the 3D CAD drawing and helped Energica mechanics to work on the

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PHOTO 1

3D printed functional prototype in Windform® LX 2.0 housing assembly and processing tests.

PHOTO 2

3D printed functional prototype in Windform® LX 2.0 housing assembly and processing tests.

development of the motorcycle. The 3D printed functional prototype was mounted directly on the motorcycle, enabling a full check of potential major issues related to the assembly of each part (machining tolerances, joint of the frame, assembly of the gears and their proper functioning, passage of cables). Thus, it provided the mechanics with functional tools in managing the critical issues that can occur while working on a prototype motorcycle.

"Being able to touch the 3D printed prototype of the motor housing – the technicians of Energica Motor Company stated – was very important for us, as we are the ones who manage fit and assembly. For example, we have been able to study first-hand if the component can be assembled and disassembled easily; if all the parts can be reached; if it is possible to use standard wrenches . . . We must put ourselves in the shoes of those who will handle the motorcycle on the market: customers, dealers and mechanics of authorized workshops.

Designing and creating a motorcycle is a team effort between designers, technicians and engineers.

We deal with technological/engineering, design, functionality issues; the final aim is to match the work of the three sectors.

The prototypes created in Windform®3D printing allow you to study the various elements, and to improve them where required by shortening development time and reducing costs.

Through the combination of LS technology and Windform® composite materials, it is possible to ensure the ongoing study of the components. The prototypes made in Windform® are 100% functional, we can mount them on the motorcycle and test them on the road and on the track. We do not waste time which, at this stage, is very precious.

2. Second step: Creation of the prototype CNC Aluminium billet

Once the CAD file has been validated, the next phase involved the choice of materials to create an Aluminum prototype.

The requirements, very similar to those required by the world of racing were:

- Performance
- Lightweight
- Resistance to temperature

The Aluminium alloys chosen were 6082 and 7075. CRP has produced the CNC machined from billet through CRP Meccanica's 5-axis production systems. CRP Meccanica is the CRP Group's specialized company in precision CNC machining for over 45 years in the most performing and demanding sectors like Motorsport and F1 (Photo 3)."

- Structure of the component

The central part, the largest, originally had a pass-through window to allow the motor to be positioned inside. Each side was a half shell of the whole.

One of the two halves was to receive the gearing housing, with a cover to seal it all in.

The pinion and oil pan are housed in the lower half of the motor housing.

The oil pan originally was created via Laser Sintering technology using Windform® GT, polyamide based glass fiber reinforced composite material. It is waterproof/oil resistant and not electrically conductive.

PHOTO 3

Aluminum billet, CNC machined motor housing prototype – setting up phase.

The innovative approach in the use of cutting-edge composite materials and state-of-the-art technologies, combined with decades of experience serving customers, has allowed the CRP Group to quickly select the most suitable materials: 6082 Aluminium alloy for the large motor housing and 7075 for lids (Photo 4).

"This phase – Energica technicians added – has been completed in a short time. CRP supported us very much, and we did not have any problem with the component, both during the bench tests and the assembly on the motorcycle: the tolerances required were very complicated and tight, as the project included two rows of bearings (those on the motor, plus the outer ones to support the output shaft).

Later, we were able to validate the road-going prototype".

2.1. Third step: rapid casting and pre-series

The following phase involved the realization of models for pre-series.

The component was manufactured by traditional sand casting process, with the same alloy used in the second phase, taking advantage from the previous experiences (Photos 5–7).

3. Application case no. 2: the dashboard

New materials enable engineers to create tougher, stronger, lighter, higher-performing components and assemblies. This can be seen with materials such as composites for Selective Laser Sintering technique: driven by demands from high performing sectors such as motorsports and automotive, the frontiers of material development will be pushed to even more extreme levels.

SLS composite materials must be suited to the application in order to have successful results. The properties of any material become increasingly important as a product progresses from concept and functional prototyping to end use.

PHOTO 4

Aluminum billet CNC machined motor housing prototype, mounted on Energica Prototipo Zero – road ready.

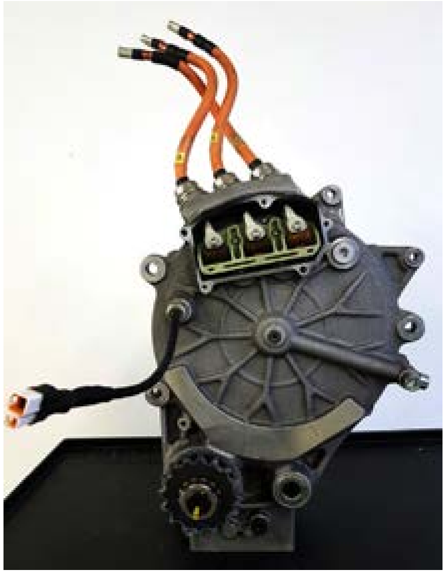

PHOTO 5

Motor housing for pre-series, manufactured via Aluminium rapid casting with sintered sand molds.

PHOTO 6

Motor housing for pre-series, manufactured via Aluminium rapid casting with sintered sand molds.

The object of this application case is the creation of the Energica motorcycles dashboard.

Right from the very start, the Energica team endorsed the idea of creating an innovative dashboard capable of containing, protecting, and isolating cutting-edge and very complex electronics: the studies and tests conducted by Energica, along with the specialized and trustworthy supplier Cobo, led to the creation a 4.3″ dashboard made up of a display with 16.7 million active matrix colors that provides excellent visibility.

The active matrix dashboard creates a real Human Machine Interface for the motorcycles.

PHOTO 7

Motor housing for pre-series manufactured via Aluminium rapid casting with sintered sand molds.

This technology allows great flexibility, supporting the flow of information and interactivity with the vehicle system. It can provide an extensive menu of configurations and advanced user diagnostics, which are easy to read.

The Energica team worked with the injection mold supplier to develop the dashboard. Both took advantage of the support and expertise of CRP Technology, the CRP Group company leader in the field of professional 3D printing with Windform® composite materials.

CRP Technology handled the construction of the functional prototypes.

> The technology of Additive Manufacturing together with Windform materials has been used to build some parts of the electric motorcycle Energica Ego, produced by Energica Motor Company. Energica Ego represents the first electric Italian motorcycle built with 3d printing technology and Windform materials. This is an important example of automotive application that opens a new path in the construction of parts of the vehicle that are ready to be used on the street. These are not simple prototype parts but they are finished-products.

CRP Technology produced three functional prototypes, using Selective Laser Sintering technology and Windform® LX 3.0, a polyamide-based composite material reinforced with glass-fibers.

On all three prototypes the development and validation activities of the components (hardware and software) and the verification of the design solutions were carried out applying specific test plans aimed at verifying both the full correspondence to the functional needs and compliance with the quality and reliability objectives required.

The decision to opt for the creation of prototypes, that would allow a thorough study to reduce the margins of error on the injection mold, is the result of a process undertaken by CRP Technology together with the Energica Motor Company team engineers.

3.1. First prototype

The shell was made in two separate parts. "Our suppliers of traditional technology (mold makers) – they stated at Energica Motor Company – would have taken roughly five months to prepare the prototype molds. Thanks to CRP Technology and the Windform® composite materials, we received the prototype in two days (Photos 8 and 9)."

The next phase involved assembling electronic components and securing them with mastic/glue. No particular difficulties or problems were found during this phase.

The Windform® prototype was then returned to Energica, which tested it by mounting it directly on the bike (in photo 3 you'll note the holder for the bike) and tested it on the road: the prototype, in conditions of extreme stress, was suitable for protecting sophisticated electronic components thanks to the construction material used. In fact, Windform® LX 3.0, is non-conductive material, ideal for producing resistant end use parts and end-applications, which can be subjected to vibrations, impacts, and multiple weather conditions.

3.2. Second prototype

The second prototype, thanks to the material's features, was painted in order to conduct color tests (Photos 10 and 11).

3.3. Third prototype

The third prototype is a hybrid version which enabled the Energica staff and mold makers to carry out precise assembly tests: this model features the lower part made by 3D printing using Windform® LX 3.0, and the upper part in plastic injection.

The tests gave positive results and the Energica engineers were satisfied: the two parts were assembled without encountering any particular problems. The plastic injection tolerances calculated are the same as those of the Windform® composite material used (Photos 12–14).

PHOTO 8

First prototype of the Windform® LX 3.0 dashboard (front).

PHOTO 9

First prototype of the Windform® LX 3.0 dashboard (back).

PHOTO 10

Second prototype of the dashboard made with Windform® LX 3.0 (painted). (front).

PHOTO 11

Second prototype of the dashboard made with Windform® LX 3.0 (painted). (back).

PHOTO 12

Third prototype of the dashboard with edge details (hybrid version: plastic injection upper part, lower part in Windform® LX 3.0).

3.4. Creation of the finished product using traditional technology (injection molding)

Once the project by the Energica team was approved, the mold makers developed the mold for industrial production.

The professional 3D printing technology and Windform® composite materials enabled the Energica team to shorten product development times, and to continue testing the component/prototype directly on the motorbike. "We used the functional prototypes of the dashboard for roughly six months,

PHOTO 13

Third prototype of the dashboard with edge details (hybrid version: plastic injection upper part, lower part in Windform® LX 3.0).

PHOTO 14

Third prototype of the dashboard (rear).

subjecting them to every kind of stress during the test rides. Thanks to the prototypes in 3D printing and Windform®, we have been able to work with the mold makers in a new way. These functional components, which are much more than just esthetic prototypes, allowed us to examine the application, and annotate some improvements for the final mold. We therefore saved time and money: when we gave the authorization to proceed with injection molding, we knew that the pieces would come out perfect and ready to be used."

Windform® LX 3.0.

Class of material:

Composite polyamide based material reinforced with glass fibers.

Technology:

Selective Laser Sintering / Additive Manufacturing.

Main characteristics:

- Improved sinterability.
- Not electrically conductive.
- High level of temperature resistance.
- Similar impact resistance properties at room and low temperature.
- Excellent surface finish in its sintered state.

4. Windform® materials

Windform® materials are laser sintering materials for 3D printing and additive manufacturing. Windform composite SLS materials were born from the study-research of R&D department of CRP Technology and international market needs. Windform® is the ideal composite SLS material that is able to satisfy the needs of international market of Additive Manufacturing. The SLS materials Windform® can guarantee originality, innovation, reliability, and mechanical performances.

5. Windform® LX 3.0

Windform® LX 3.0 is a composite polyamide based material which is reinforced with a new generation glass fiber system. Windform® LX 3.0 has improved the already excellent performance of Windform® LX 2.0. These improvements can be noticed from a sinterability standpoint. Windform® LX 3.0 maintains the Windform® LX 2.0's technical and thermal properties; it is also not electrically conductive. It is a naturally black material and is characterized by good Tensile Strength and stiffness. Windform® LX 3.0 is also characterized by high level of temperature resistance (HDT, 1.82 Mpa is 175,9 °C/348.62 °F).

Windform® LX 3.0 has an excellent surface finish in its sintered state; it is perfect for components with fine details. Windform® LX 3.0 is highly recommended for applications that require a strong visual impact and for esthetical parts.

Windform® LX 3.0 is an entry-level material and is perfect for creating functional prototypes or finished parts that require reliability, resistance and esthetical properties. Windform® LX 3.0 has been rated HB according to the flammability UL 94 test.

6. Windform® GT

Windform® GT is a polyamide based glass fiber reinforced composite material with a dark black color. After hand polishing, the material is smooth with a deep lustrous finish.

Windform® GT is a flexible product in the Windform® family of materials for additive manufacturing, not only esthetically, but also in terms of performance.

Windform® GT combines the optimal characteristics of elasticity, ductility, and resistance to impact. Thus, it can be considered a highly valuable material in various racing and functional applications in regard to vibration and shock. The material's superior values in regard to impact strength and elongation at break, combined with its tensile and flexural strength, make it ideal for applications where resistance to "damage" is a prerequisite in order to preserve internal components in the event of impact and/or improper use.

Windform® GT is also a waterproof material, with resistance to the absorption of moisture and liquids. It is also very light with excellent mechanical properties per unit density.

Windform® GT is a not electrically conductive material.

Windform® GT has been rated HB according to the flammability UL 94 test.

Windform® GT.

Class of material:

Composite polyamide based material reinforced with glass fibers.

Technology:

Selective Laser Sintering/Additive Manufacturing.

Main characteristics:

- Excellent characteristics of elasticity combined with high resistance to impact.
- High flexibility and resistance to damage.
- Not electrically conductive.
- Waterproof material.

7. CRP Technology e CRP Meccanica

CRP Meccanica and CRP Technology are headquartered in Modena, Italy. They are dedicated to providing clients with the very latest technological solutions in Subtractive Technology (or high precision CNC machining with CRP Meccanica) and Additive Manufacturing (or Advanced 3D printing with Windform composite materials, CRP Technology).

CRP Meccanica and CRP Technology are distinguished by their know-how in specific application fields including but not limited to: automotive and motorsports, design, aerospace, UAVs, marine, entertainment, defense, and packaging.

CRP Technology offers part production for short- and low-run production, and prototyping services with advanced 3D Printing and Additive Manufacturing solutions. As a material provider, CRP Technology develops, manufactures and sells its proprietary material Windform® for Laser Sintering.

Video to share: https://www.youtube.com/watch?v=rb4htZSKTNM

FEATURE

When haute couture fashion meets biomimetic design

Benedikt Borchert

Complex components in medium to high volume require lean manufacturing technologies that allow for efficient material usage as well as precise and reproducible production. Thanks to 150 years' experience in haute couture embroidery, BIONTEC efficiently produces CFRP components in high volume.

Tackling high cost of composites

Fiber reinforced composites offer many properties that allow a technically better solution compared to metallic materials: These cover, among other things, the high specific mechanical properties, which predestine the material for lightweight construction, but also low thermal expansion, a high degree of vibration damping and the integral design possibilities. However, major challenges lie in the design of the anisotropic material as well as in the often high costs. With the prevailing manufacturing techniques for carbon fiber reinforced plastics (CFRP), an economic use of the material, especially in medium to large quantities, is hardly conceivable.

BIONTEC's novel approach: textile technology and biomimetic design

Based on 150 years' experience in textile technology combined with comprehensive know-how in fiber reinforced plastics the company has developed its own manufacturing process from fiber to finished component for large serial production (Figure 1).

BIONTEC adapted Tailored Fiber Placement (TFP) for high volume production and thus allows an efficient and robust preform manufacturing.

By sewing the reinforcing fiber onto a carrier material the optimum material combination for each specific challenge can be chosen. According to biomimetic design BIONTEC aims to achieve the best performance with minimum material usage by placing fibers aligned to the load path within the net shape of the component. By combining different layers of fiber into one stitched layup preforming can be simplified significantly. For more complex parts, several layups are combined like a puzzle into a three-dimensional stable preform. A high degree of automation reduces costs and typical defects such as gaps, fiber misalignment, wrinkles and so forth.

The component is molded net shape using Resin Transfer Molding (RTM) minimizing machining efforts. Due to infusion optimized preforms and multi-cavity tooling, short cycle times can be achieved without the use of high-pressure RTM systems, thus being the less prone to process induced defects (Figure 2).

Engineered to perform: from idea to serial production

BIONTEC develops components from first idea until serial production. Every single step in development is taken on the premise of enabling efficient production – whether the customer requires 100 or 100,000 parts per year. By using the vast knowledge in textile technology as well as composite production a product designed for manufacturing is obtained (Figure 3).

Wide range of products

The technology is particularly suited for complex parts that are rather limited in size. Parts can be manufactured monolithic, with sandwich cores, or even hollow, depending on the specific requirements. Typically, high tenacity or high modulus carbon fibers are employed but other technical fibers such as glass, basalt or aramid fibers are used for special applications for example in medical technology.

A few fields of applications stand out:

In metrology, especially when it comes to optical handheld devices, weight, stiffness and thermal expansion are drivers for applying carbon fiber composites. With the freedom of fiber steering combined with the automated manufacturing process, superior mechanical performance together with minimal variation can be achieved. Typically these products employ high

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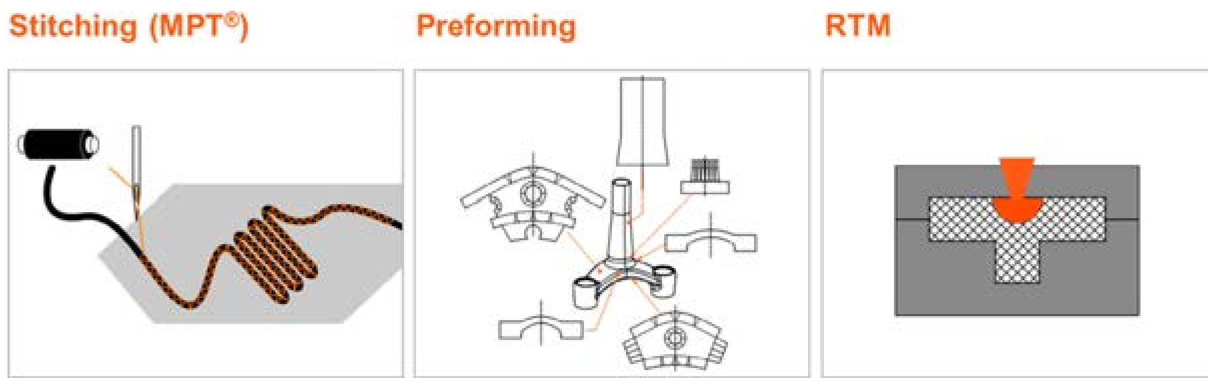

FIGURE 1

Composite manufacturing process optimized for serial production.

FIGURE 2

Net shaped stitched textile, 3-dimensonal preform and molded and machined part – bicycle brake lever for high-end brake systems offering 50% weight saving over forged and milled aluminum levers.

FIGURE 4

Structure for a 3D scanner featuring stiff sandwich structures and high surface quality out of mold.

FIGURE 3

Engineering steps from first concept over CAD and FEA to production focusing on performance and efficient manufacturing.

FIGURE 5

Corner cleat designed for a small satellite structure in high volume (>1000 ppa).

modulus fiber and special resin systems reducing process induced deformation such as spring in. Furthermore, the automation and short cycle time of the process allow significantly higher productivity than commonly applied prepreg hand-layup, thus cutting costs by half (Figure 4).

At the other end of the volume range the typical products being replaced are forged or die cast aluminum. Using automation, multi-cavity tooling and fast-curing resins, production rates of 100,000 ppa can be achieved. Key enablers for such high volumes are net shaped preforming and molding in order to reduce material waste and machining efforts to a minimum. Using ideal fiber orientations in a component can increase potential weight savings up to 50 % over aluminum, as several serial production parts from the bicycle industry show.

Other applications are the replacement of milled aluminum or titanium fittings for aerospace and space industry where performance and part consistency can be well met. Such a structure for a scientific space mission in which, besides mechanical performance, thermal expansion, thermal stability and outgassing are the critical qualification criteria, is currently in development. For these purposes a new cyanate ester resin for infusion has been utilized (Figure 5).

FEATURE

An interview with Boston Materials

Callum McGuire, Boston Materials

Reinforced Plastics sat down with a representative of Boston Materials to learn about their Carbon Supercomposite.

Tell us a bit about Boston Materials and its history

"Boston Materials designs and manufactures Carbon Supercomposite — a new class of carbon fiber composite that enables durable, safe and unique parts. Carbon Supercomposite is the first composite material that features both 3D and interlaminar reinforcement and is available in both prepreg and dry fabric form to enable immediate integration into existing manufacturing workflows.

"Boston Materials was founded by Anvesh Gurijala (founder and CEO) and Michael Segal (founder and COO) in 2016 as a Northeastern University spin-out and has its foundations in the breakthrough work done at Dr. Randall Erb's Northeastern Directed Assembly of Particles and Suspensions (DAPS) laboratory. In recent months, the company has moved its operations to a 5000 square-foot facility in Bedford, Mass. (20 miles north of Boston), and hired Chief Commercial Officer Kedar Murthy — who has significant experience in bringing new and novel materials to market — to drive revenue growth, secured funding from Boston-based Clean Energy Ventures and SABIC Ventures, and installed a production line in preparation for a product launch this summer."

What is carbon supercomposite?

"Carbon Supercomposite is a carbon fiber composite that uses a proprietary fiber alignment technology to vastly improve the performance of existing carbon fiber materials, unlocking a host of new applications and improvements to existing and future designs and structures. Boston Materials' technology improves toughness and strength and allows for enhanced electrical and thermal conductivities. Its application is crucial to the advancement and improved efficiencies of the pressure vessel, wind energy, sporting goods, automotive and aircraft markets, and beyond."

E-mail address: McGuire, C. (c.mcguire@elsevier.com)

What distinguishes carbon supercomposite from other, traditional 2D composites?

"Carbon Supercomposite was created to overcome the shortcomings of traditional composites with a patented fiber reinforcement that delivers highly differentiated functionality and performance.

"Durability with stiffness – Carbon Supercomposite utilizes advanced methods to toughen conventional composite materials without sacrificing strength or stiffness. Milled fiber reinforcement in the Z-axis increases toughness by 300 percent and strength by 35 percent without any detriment to stiffness.

"Safety via plastic deformation — with Carbon Supercomposite, failure is preceded by signs of deformation due to delamination pinning. This allows end users to register a change in apparent stiffness of a composite, presenting an opportunity to repair or replace the component prior to catastrophic failure."

Tell us more about the processes involved in creating a unique, 3D reinforced, carbon fiber

"Carbon Supercomposite is formed by coating a standard carbon fiber fabric with milled carbon fibers. The milled fibers are oriented vertically using a proprietary technology. Our process is solvent free, low energy and generates very little waste. It truly is a novel approach to making a three-dimensionally reinforced material."

Tell us a bit about the prepreg variants of carbon Supercomposite

"We call it 'Out-of-the-Box Compatibility,' which means faster time to market for our customers. Carbon Supercomposite products are compatible with all crimp and non-crimp fabrics, including carbon fiber and non-carbon fiber, in addition to existing layup methods, including automated tape laying. Prepregs are

0034-3617/ https://doi.org/10.1016/j.repl.2019.07.001

available with standard 250°F and 350°F cure epoxy resins; however, unique resins can be produced upon request. Prepregs are available up to 12-inch widths and up to 50-yard lengths. Because our process is fabric and resin agnostic, we are working with several customers with different fabric and resin combinations."

And how does the Supercomposite perform in comparison to its peers?

"Traditional carbon fiber composites lack toughness and high multi-axial performance. This is exacerbated under compression where planar compressive forces manifest as a combination of Mode I and II loads. The Z-axis milled fibers mechanically pin the layers of a laminated composite together, drastically increasing the interlaminar fracture toughness. This patented interlaminar toughening mechanism effectively distributes multi-axial loads throughout the entire composite and provides bulk toughness of over 12 megajoules per cubic meter, demonstrating a 300 percent enhancement over current carbon fiber composites."

How easily can the Supercomposite be integrated into pre-existing production processes?

"Supercomposite products were specifically designed to integrate into pre-existing production processes so that customers did not need to change the process they have become accustomed to. Our initial products are being sold as prepregs for use in traditional composite layup processes. We will also be launching dry fabric to allow customers to use their own resin systems in resin transfer molding (RTM) RTM or vacuum assisted resin transfer molding (VARTM) processes."

What is the range of applications for your carbon Supercomposite?

"Carbon Supercomposite brings new design improvements and performance benefits to demanding materials applications.

"Sporting goods: Protecting users while elevating product performance is the ultimate goal. Carbon Supercomposite is a powerful tool that delivers a competitive edge with a new level of safety by enabling the production of tougher parts that show signs of deformation before failure.

"Oil and gas: Corrosive and abrasive environments make it challenging to deliver components that resist wear over a longer lifespan. Integrating Carbon Supercomposite in products can provide a unique combination of compressive strength and wear resistance.

"Pressure vessels: Higher pressure and safety requirements for Type IV and V pressure vessels make repeatable production of durable carbon fiber composites a top concern. Carbon Supercomposite allows users to simplify their designs and increase manufacturing productivity.

"Automotive: Safety is the top priority for crash structures and battery packs. The toughness of Carbon Supercomposite can enable lightweight components and structures that can take a hit.

"Aerospace: Durability of high-temperature, sub-components like carbon seals is a critical safety issue for modern aircraft. Carbon Supercomposite can be used to produce tougher and more shock-resistant materials."

How does the carbon Supercomposite compete with metal alloys for performance?

"One of the main goals at Boston Materials was to help the industry bridge the gap between old-school metals and new-age composites. A composite with increased toughness, higher through-thickness performance and ductile fracture mechanics is a big step in that direction."

Are there any markets you would like to work with that have not adopted the carbon Supercomposite?

"As a materials company, we are interested in any and all market opportunities where our Supercomposite product can provide a substantial improvement over the status quo. While the initial focus is applications where composites are already being used, the significant mechanical, thermal and electrical property improvements demonstrated by Supercomposite products opens the door for applications where composites have yet to be utilized due to their inherent limitations. For this reason, we are very open to, and interested in, partnerships and development work with component manufacturers that are designing parts with either composites or metals."

What would you say are the challenges of continued innovation in the composites market?

"Once an industrialized market reaches some level of maturity, it is faced with the challenge of recycling; the composites industry is no different. Scrap rates in the total supply chain from virgin carbon fiber manufacturing to part production is about 30 percent. Boston Materials addresses this in part by using milled carbon fibers in the Z-Axis to provide mechanical reinforcement. Milled carbon fibers produced in the carbon fiber and weaving processes would otherwise be landfilled or sold into lower value filler applications. Boston Materials repurposes these fibers in the production of Supercomposite products, ultimately creating a higher value product.

"We are also starting to see the adoption of thermoplastics in automotive and aerospace so it was important for us to make sure our products were compatible with both thermoset and thermoplastic resins. This was the motivation behind working with SABIC, a leader in the thermoplastics industry.

"Finally, there is significant value in composite adoption by the automotive industry to provide an effective method of reducing greenhouse gas emissions through lightweighting. The main hurdle here is getting composites to be cost competitive with their metal counterparts. Boston Materials Supercomposite hopes to help by bringing a higher performing material to market at a similar cost per weight as traditional composites to help offset the cost."

What's next for Boston Materials?

"Our production line has arrived, and we will launch our first Supercomposite products in July with several customers who will validate the material; it's quite exciting to be able to take this from the idea stage to full-scale production. For us, the key is driving growth, adopting products in the applications mentioned and partnering with companies along the supply chain where we can provide added value."

FEATURE

Increased market role for long fiber thermoplastics

Mark Holmes

Long fiber thermoplastics continue to expand into traditional composite market areas, benefitting from better recyclability and the need for improved production cycle times. *Reinforced Plastics* looks at some recent developments.

Thermosets still dominate the global composites materials market, however, there has been a significant shift towards thermoplastics, with long fiber materials being an important part of the transformation. At the recent Advanced Engineering Show – Composites Forum, Nigel O'Dea, Business Development Manager Europe at Lucintel reported that while the global composites market has grown from US$23.9 billion in 2013 to US$29.9 billion in 2017, the proportion of the total for thermoplastic composites had grown from 25% to 39% in the four-year period. He emphasized that the shift to thermoplastics is expected to continue, driven by easier recyclability and faster production cycle times. Thermoset composites are still likely to be predominantly used in construction, pipe and tank, wind turbine blades, marine, and electrical and electronic, while thermoplastic applications are expected to grow in aerospace, automotive and transportation, and consumer goods.

One company at the forefront of long fiber thermoplastic (LFT) composite developments is US-based PlastiComp. Its acquisition by PolyOne Corporation in June 2018 brought new opportunities for the organization to grow. Founded in 2003 by Stephen Bowen, PlastiComp has steadily grown its long fiber technology for metal replacement and lightweighting applications. The company's Complēt™ LFT product lines and design capabilities are serving global customers in a wide-range of demanding applications, including automotive, medical devices, robots and drones, marine, and outdoor high performance equipment (Figure 1). PlastiComp's 50 employees and its design and production facility in Winona, Minnesota, USA join PolyOne as part of its Specialty Engineered Materials segment.

"As we looked to take this business and our customers to the next level, PolyOne was the natural choice," says Stephen Bowen. "PolyOne's comprehensive approach to design, service and innovation in thermoplastics and composites will enable us to forge even further ahead with our LFT technology, and I am excited that our teams have joined together in collaboration for the future."

According to PlastiComp, the market for long fiber thermoplastic composites is robust. Driven by the automotive sector, replacement of metals by high performance thermoplastics continues to gather momentum while new applications for high strength plastic compounds are growing in other industries as well. The company adds that long glass fiber reinforced polypropylene materials for the automotive sector currently dominate production, but there is also growth occurring on a smaller scale in engineering resins, such as polyamides, for other markets such as sports and recreation and industrial equipment.

Lightweighting and metal replacement continues to be the driving force behind the adoption of long fiber materials. Factors such as increasing fuel economy and emissions regulations are the driving motivation for the automotive industry to convert components to lighter materials, but in other market segments the rise of hand-held and portable devices is also promoting the use of alternative materials. The simplification of manufacturing and product assembly is another high motivator for designers and engineers to be looking at long fiber materials, whether an application has structural requirements or needs to be highly durable, which is a necessity for hand-held and portable devices, says the company.

PlastiComp sees new material and product developments as predominantly iterative, more geared toward customizing long fiber formulations to meet the performance requirements of specific applications. This is often obtained through additives being combined with the polymer matrix during pultrusion to gain additional performance characteristics. However, from a technology perspective there are moves to increase production

  https://doi.org/10.1016/j.repl.2018.12.071

FIGURE 1

Complēt™ long fiber thermoplastics from PlastiComp.

throughput in pultrusion, while maintaining wet-out and quality standards.

PlastiComp adds that materials with improved surface appearance are a particular area of interest at present. Traditionally long fiber was used for internal structural elements that were seldom visible; so fiber present on the surface was not a concern. However, the company says that it is now becoming more common for components made with long fiber to be used for exposed surfaces. As a result, smooth fiber-free appearance is much more critical than in the past. PlastiComp has also developed some polyamide materials that are less susceptible to performance degradation from moisture absorption. This is a factor for applications that will see exposure to a wide variety of climates – manufacturers commonly and erroneously expect that their end products will function the same in a tropical environment as they do in an arid one.

PlastiComp manufactures long fiber reinforced composite materials by combining all types of continuous fiber, such as glass, carbon, or specialty fibers into any thermoplastic polymer matrix – from polypropylene to PEEK. Examples of recent applications include a molded long carbon fiber composite for wheelchair caster wheels that are 33% lighter and have a molded pivot point design that allow them to function like aircraft landing gear to provide a smoother ride (Figure 2). Another application has included a long fiber composite material for a motorboat propeller system that makes use of interchangeable blades to lower repair costs and fine tune performance (Figure 3).

During 2018 PolyOne Corporation has also collaborated with Integral Technologies Inc. and its wholly owned subsidiary ElectriPlast Corporation to commercialize its long fiber conductive ElectriPlast® material. This highly engineered, filled thermoplastic polymer replaces metal in electromagnetic and radio-frequency (EMI/RFI) shielding applications at up to 60% lighter weight. Through an exclusive, ten-year license agreement, ElectriPlast technology will serve as a complement to PolyOne's existing specialty engineered materials portfolio, providing shielding for advanced driver assist systems (ADAS), including housings, connectors, and internal components for cameras, sensors, and electronic control units (Figure 4). As the automotive industry moves to incorporate more ADAS technologies, the need for EMI/RFI shielding to eliminate cross talk has grown, because shielding is essential to the systems' operation. With ElectriPlast's Flexible Content Technology (FCT), the percentage and kind of metal fibers can be tailored to meet each OEM's specifications.

FIGURE 2

PlastiComp developed a molded long carbon fiber composite for wheelchair caster wheels that are 33% lighter and have a molded pivot point design that allow them to function like aircraft landing gear to provide a smoother ride.

FIGURE 3

A long fiber composite material from PlastiComp was used for a motorboat propeller system that makes use of interchangeable blades to lower repair costs and fine tune performance.

EMS-Grivory has also been supplying long fiber thermoplastic solutions for the automotive industry. In collaboration with the Lear Corporation and the automotive manufacturer Opel, based in Rüsselsheim, Germany, the company has developed the back support and seat shell for a sports seat made of Grivory GVL HP for the new Opel Insignia GSI model (Figure 5). The special long glass fiber reinforcement of the material forms a fiber skeleton during the injection molding process, which significantly increases the notched impact strength values and allows higher energy absorption in the case of a crash. Compared to a similar metal version, a weight saving of two kilograms was achieved. EMS-Grivory says that it employed CAE calculations and

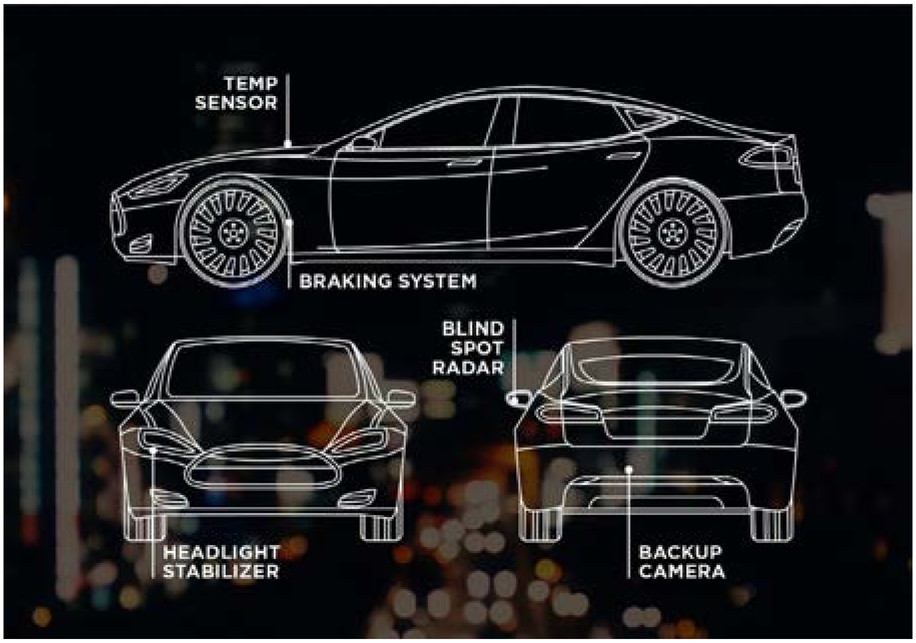

FIGURE 4

ADAS components using long fiber conductive ElectriPlast® material include backup cameras, blind-spot-monitoring radar and sensors for monitoring environmental conditions and enhancing performance.

FIGURE 5

EMS-Grivory has supplied Grivory GVL HP long fiber thermoplastics for the back support and seat shell in a sports seat made for the new Opel Insignia GSI.

technical support during processing to achieve this challenging application.

The company has also developed Grivory HT1VA, a long fiber reinforced polyamide, for cooling system applications in electric vehicles. Liquid-cooled, water-based systems are often used, which require good hydrolysis and temperature resistance properties. EMS-Grivory adds that thermal management is important for efficient running of electric vehicles; in particular to maintain the high voltage battery, power electronics and electric motor at the correct temperature level. The new material offers good resistance to hydrolysis and cooling agents and can withstand long-term use at moderate cooling agent temperatures. After around 12,000 h in water at 95°C, Grivory HT1VA exhibits 30% higher strength values compared to a traditional PPA under the same conditions. A further advantage is its electro-compatible stabilization, which makes it suitable for electronic components. In combination with electrical conductors there is no ionic migration and in warm climates, no corrosive effects are created. Applications in cooling systems include auxiliary water pumps and thermal management modules.

EMS-Grivory is also supplying Grivory GVX-6H for the air vent lamella of the current Audi Q7 series, manufactured by The Dr. Schneider Group. The lamellae are up to 335 mm long and as this is a visible part, excellent surface quality is necessary along the whole flow length. Swirls near the gating system caused by wrongly oriented glass fibers – the material has 60 wt.% glass fiber reinforcement – must be avoided and a precise ventilation system in the mold is needed to prevent surface porosity. Exact dimensional adjustment between the lamellae, housing and support is also essential. The partially aromatic polyamide Grivory GVX-6H met all these requirements. Along with its good surface quality and chemical resistance, the material has high dimensional stability, as well as maximum stiffness and strength. Its good flowability also ensures optimal processability, says EMS-Grivory (Figure 6).

Fibremod CFPP range of carbon fiber-reinforced polypropylene grades from Borealis are now also finding commercial applications in the automotive sector. The company says that Fibremod CFPP compounds are engineered to achieve lightweight, integrated and high-performing solutions as a suitable replacement for many conventional engineering plastics used in the automotive industry. Borealis CFPP grades are lightweight and exhibit extreme stiffness, as well as good processability. Unlike polyamides, CFPP is not hygroscopic – so does not absorb moisture. Compared to other plastics, CFPP products help minimize ‘squeak and rattle’ noises.

Fibremod CB061SY has been used by a leading North American OEM to make the A-pillar brackets on a top-selling commercial vehicle. Although only 6% carbon fiber-filled, the product offers a stiffness of approximately 4000 MPa, and a density of 0.93 g/cm^3. This has achieved a significant weight savings without having to compromise on performance requirements. In addition, having modified an existing tool capable of producing a viable thermoplastic alternative to a conventional metal-stamped part, Magna Exteriors selected a Borealis Fibremod Carbon development grade containing 10% carbon fiber-reinforced engineered polypropylene. This enables the manufacturer to achieve both the exterior part impact performance required for crash and pedestrian safety, and the high-quality look of a class-A painted part. However, because the part is made of reclaimed Fibremod Carbon Fibre, the body panel weighs 30–40% less than conventional aluminum panels, and enables zero gap performance with very low CLTE when compared to other engineering plastics. This makes the exterior application more recyclable, lighter weight, and therefore more sustainable (Figure 7).

Lanxess is continuing to develop the Tepex range of continuous fiber-reinforced thermoplastic compounds (Figure 8). The company says that they are becoming increasingly important for lightweight vehicle design and can be found in an increasing number of series production applications – for example, front-end mountings, underfloor protection and bumper beams, brake pedals, through-loading systems and fuel tank reinforcements. There is also significant potential for use in vehicle underbodies, for the protection of batteries and in new concepts for highly-integrated, multi-position seats. Lanxess is currently developing composite variants with electromagnetic shielding properties, especially for components of electrified vehicle drivetrains. Tepex can also be used to fabricate virtually indestructible engine compartment trim, fuel tank covers and center tunnel covers, like those already in use in several standard models, such as the Bentley Bentayga SUV. These compounds are also suitable for manufacturing stiff, strong, thin-walled components, such as device mounts with high functional integration, versions of which are already in use in several standard models.

Coventive Composites has developed long natural fiber thermoplastic, injection moldable composites using flax, hemp and jute fibers in a polypropylene matrix as a cost-effective alternative to long glass fiber thermoplastic products in automotive applications. The company says that glass fibers are relatively heavy, derived from non-renewable sources and cannot easily be recycled. By contrast, natural fibers are less dense than glass and have a lower environmental impact. They also have a similar stiffness to glass fibers. The pellet format and method by which they are produced also helps to preserve the reinforcing proper-

FIGURE 6

EMS-Grivory is supplying Grivory GVX-6H for the air vent lamella of the current Audi Q7 series.

FIGURE 7

Class-A fender part produced with Borealis Fibremod Carbon by Magna Exteriors.

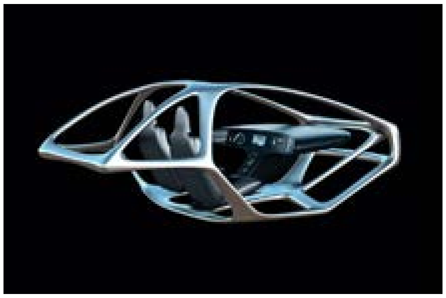

FIGURE 8

Lanxess is developing the Tepex range of continuous fiber-reinforced thermoplastics for lightweight vehicle design.

ties of the natural fibers; these are often compromised in other more aggressive production processes. The pellets are typically a 50:50 mix by volume of natural fibers and polypropylene fibers. They are currently produced using Coventive's in-house pilot line at a length of between 5 and 25 mm, depending upon the requirements. The pellets can then be injection molded using standard equipment. Because natural fibers are less abrasive than glass, they also generate less tool wear.

Conventus Polymers has developed a range of high performance thermoplastics using long fiber technology that deliver high strength, high heat resistance and dimensional stability for firearm applications including stocks, magazines, receivers, rails, and a variety of other applications. The company says that polymers are increasingly employed in the firearms market. In addition to lightweighting, they offer reduced recoil, corrosion resistance, serviceability, cost benefits and design freedom. Conventus Polymers says that it has used its expertise in other high-performance markets such as downhole oil and gas, where temperatures and pressures can be very high. The company's primary product categories are specialty polyamides, glass fiber and carbon fiber reinforced composites, and long glass and long carbon fiber reinforced materials.

Conventus says that it recently worked with a manufacturer to customize a long carbon fiber reinforced PA6.6 resin that offers high modulus and good creep resistance and strength without compromising impact resistance that short carbon fiber would impart. This was achieved using a combination of long carbon fibers and an impact modification package. Standard long glass reinforced resins did not offer sufficient strength. The company has also developed a new line of long fiber technology in custom MIL-SPEC colors and soft-touch polymers in custom colors. These have been used in magazines and helmet components, such as rails.

Long fiber properties in short form

One company offering an alternative approach to reinforcement is US-based Piper Plastics, which claims it has developed a short fiber thermoplastic material that outperforms the mechanical strength of long fiber thermoplastic (LFT) materials. The KyronMAX™ series of structural thermoplastics is designed for injection moldable metal replacement technology.

"Our customers wanted the strongest moldable polymers available without all the process and design limitations associated with LFT polymers," says David Wilkinson, Polymer Technology Manager at Piper Plastics. "KyronMAX materials consistently outperform LFT polymers, especially when measuring the performance of the molded part, which is the true test. They overcome all the limitations associated with LFT compounds while yielding stronger molded parts that are also lighter in weight."

Piper Plastics says that KyronMAX is based on short fiber technology that allows the polymer to behave more like the isotropic nature of metal and eliminates the processing and fiber breakage concerns associated with LFT compounds. The technology enables complex parts to be molded with good mechanical performance and consistency. A feature of short fiber technology is that complex parts can be molded with wall thicknesses down to 0.038 cm (0.015 inches). Competitive structural compounds use high fiber loadings and long fiber lengths to achieve the desired mechanical performance, but the performance of these materials often do not translate into the molded parts, due to weld line strength loss and fiber length reduction during processing. In contrast, KyronMAX technology is claimed to outperform all other thermoplastic compounds using short fiber technology and much lower filler loadings.

"The lower filler content results in a tough, structural plastic that can be utilized in extremely aggressive applications, yet is still processing friendly and does not require specialized molding equipment," says Wilkinson. "We are consistently replacing LFT polymers with KyronMAX polymers that are 20% lighter and 20–50% stronger. Exhibiting tensile strengths above 51,000 psi (352 MPa) and flexural modulus above 6,500,000 psi (44,816 MPa) the KyronMAX technology platform is currently formulated in various thermoplastics including PA, PPA, PPSA, PEI, PEEK, with more in current development."

Piper Plastics adds that manufacturing of KyronMAX is a multi-step process, which utilizes customized processing equipment developed by the company. The procedure starts with raw materials that are processed and modified in-house to ensure that the highest standards and consistency are achieved. The raw materials are then processed into compounds using custom-built equipment to achieve the required levels of mechanical performance. The constituents and formulations are specifically designed for a customer's end use applications (Figure 9).

FIGURE 9

Piper Plastics claims it has developed a short fiber thermoplastic material that outperforms the mechanical strength of long fiber thermoplastic materials.

FEATURE

Long fiber thermoplastics are a key technology in expanding existing markets for composites

Django Mathijsen

Long fiber reinforced thermoplastics (LFT) are like the middle child of reinforced plastics technology. They are sometimes overlooked but hold the composites family together by bridging the gap between low-cost short fiber filled thermoplastics and heavy-duty fabric reinforced engineering polymers. We talk to the specialists of PlastiComp, a company dedicated to expanding the application of LFT.

"Because the two big suppliers in the industry, SABIC and Celanese, were so focused on the automotive industry, I thought there was an opportunity to take this material technology and concentrate on non-automotive markets," says Steve Bowen, the president of PlastiComp. He has 35 years of experience in the long fiber industry and started PlastiComp in 2003. "We founded the company to take LFT into new areas by not following the masses."

Automotive and transportation are the largest markets for LFT, but they are mostly processing glass fiber reinforced polypropylene. PlastiComp concentrates mainly on engineering thermoplastics, such as nylons, tackling solutions that are neglected by the large suppliers and which often pose more of a challenge. "We are interested in innovation, partly because the others do not look at it so intently," Bowen explains.

PlastiComp is primarily a materials company, producing and selling LFT pellets (Figure 1). But because many people are unfamiliar with LFT technology, the people at the company help out their clients with concept and development work, engineering and computer analyses. And they have pretty comprehensive resources on their website, including a white paper which introduces people to LFT technology (https://www.plasticomp.com/long-fiber-design-principles-white-paper/).

Eric Wollan, PlastiComp's general manager, who moved up from engineering, says: "We help to develop the application, and optimize the materials we sell." Applications they have helped to develop range from a wheelchair wheel (Figure 2) to a motorboat propeller (Figure 3a,b,c).

As a US-based company, PlastiComp mainly has US customers. But because it was acquired in June 2018 by global plastics formulator PolyOne Corporation, which has a much larger worldwide footprint, it is set to expand. "We are now able to serve customers globally with the same material," Bowen says.

1. Fiber orientation and parts consolidation

Composite materials are always stronger in the direction of the fibers. So, it is important to be able to tailor the fiber orientation inside the material to the stresses the part will be subjected to during use. Controlling that fiber orientation is easy with lay-up techniques, but they are a rather expensive and time-consuming form of manufacturing. Long fiber thermoplastics are typically processed via injection molding, which is much faster and cost-effective, but poses more of a challenge in controlling fiber orientation.

"You can introduce some control by how you design the part and where you set up the gate," Wollan says. "That is the place where you are injecting the material."

An example of that can be seen in an archery crossbow riser PlastiComp helped to develop (Figure 4). "They tried for years to make that work in short fiber without success," Bowen says. "Where the two flow fronts meet in the mold, you get a weld line which is a weakness in the material because there is no fiber crossing over between the two different flow fronts. Traditionally, if you would have gated the riser symmetrically, you would have had the weld line right at the location of highest stress. So, we moved the gate." More about this archery riser in the white paper.

Oftentimes LFT technology is used to replace a part that was previously done in metal. Of course, the design of the metal part cannot be transferred directly to the LFT version. The first step in designing an LFT version is understanding the exact forces the part will be exposed to. "A lot of times the part is overdesigned

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FIGURE 1

a,b: PlastiComp primarily produces and sells LFT pellets (Photo courtesy PlastiComp).

in metal," Bowen says. "If we get involved early on, we can recommend the proper design and material for long fiber. It could be carbon, glass or a carbon and glass hybrid."

The next step is optimizing the design using Computer Aided Engineering and Finite Element Analysis, which shows the stresses the forces will cause in the part (Figure 5). "And then you try to design the part so that the material flows, and you get the right fiber orientation in the areas of highest stress," Wollan explains. By changing the part design, the wall thicknesses and the gate location, you dictate the fiber orientation to some extent (Figure 6). "We run mold flow analyses to get an idea of the fiber alignment in the part and see if we have to make any additional changes based on weld lines or if the fiber alignment doesn't look like it is going to be enough in the direction of the stresses in key locations. Typically, we go through many iterations to get to a final part design. But the process is fast and inexpensive."

"Yes, Computer Aided Design has really sped up the process," says Bowen. "Previously, you had to make prototypes and test them. That could take years. Normally, there is an advantage to do more than one part together. Part consolidation is a big economic advantage when we are going from metal to LFT. We look more at function replacement rather than part replacement."

2. Expanding markets

Choosing long fibers as reinforcements instead of short fibers is usually done because it gives the material a large performance boost in toughness and durability, that is: in fatigue resistance and impact resistance. "We have test results that show twenty times more fatigue resistance than short fiber," Bowen explains. But since LFT is more expensive, it does not compete with short fibers. Engineers and injection molders tend to go to long fibers –

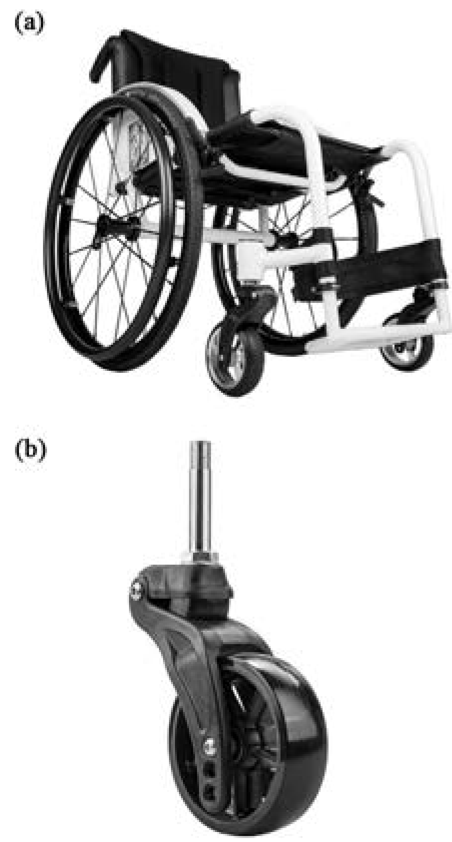

FIGURE 2

a,b: PlastiComp helped to develop the casters of this innovative wheelchair. Instead of metal, long carbon fiber reinforced nylon 6/6 is used for the forks, and long carbon fiber reinforced thermoplastic polyurethane for the hub (which allowed for an excellent chemical bond to the urethane used for the outer rolling surface). The wheels are 33% lighter than the original aluminum versions (Photo courtesy PlastiComp).

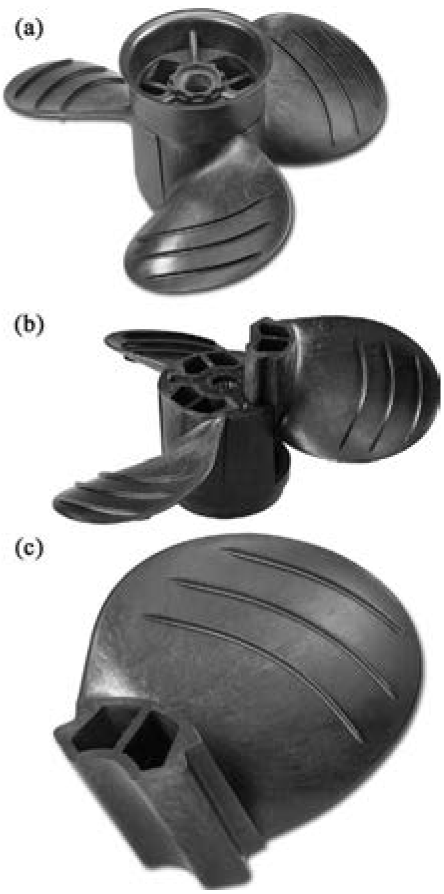

FIGURE 3

a,b,c: The blades of this long glass-fiber reinforced nylon 6 propeller will flex in a minor impact, absorbing the energy. In case of a major impact, the blades will sacrifice themselves by breaking off, due to a lower shear strength than metal. Because the blades are interchangeable, they are much cheaper to replace than a conventional one-piece metal propeller (Photo courtesy PlastiComp).

FIGURE 4

PlastiComp helped to develop an archery crossbow riser (Photo courtesy PlastiComp).

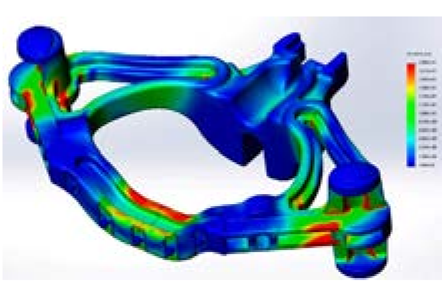

FIGURE 5

Finite Element Analysis of the crossbow riser (Photo courtesy PlastiComp).

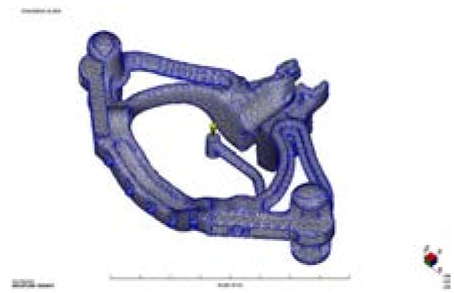

FIGURE 6

Optimizing the design only for stress is not enough. The mold flow and its resulting fiber orientations have to be analyzed as well. With the crossbow riser, in order to prevent a weak spot, it was necessary to move the gate so that the material flowed into the mold asymmetrically. (Photo courtesy PlastiComp).

which can be used in the same process equipment – if they cannot achieve the required properties for a part using fillers and short fibers. "We will often work with the customers and realize results where they tried for several years to make the part work in short fibers without success," Bowen says.

Long fiber thermoplastics expand existing markets of injection molded plastics because their properties are closer to the performance of metals, enabling more metal parts to be substituted by plastic ones. "We are also lighter and more economic if we combine parts," Wollan says. "The largest market clearly is automotive. Maybe eighty percent of the world's LFT is going into auto parts. That was initially fairly simple with glass fiber and polypropylene creating most of the success. Today, we see more engineering materials and long fiber being considered."

So, material succession and increasing the market for composites is an ongoing progression of events, for example starting simple, with glass fiber reinforced polypropylene, and gradually going to engineering polymers and higher performance fibers as more metal parts are being substituted. This becomes more and more specific to the applications (Figure 7). "Hybrid fibers offer better economics with higher stiffness," Eric says. "And we think of more reachable opportunities by combining technologies like unidirectional (UD) tape and overmolding with LFT composites." (Figure 8) In overmolding, this UD tape is great for strengthening key details like connecting points or hinge points (Figure 9). But it is fairly limited in its movement within the molding operation. Combining it with LFT increases the

FIGURE 7

Hybrid – glass and carbon – fibers offer better economics with higher stiffness (Photo courtesy PlastiComp).

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FIGURE 8
In overmolding, unidirectional (UD) tape can be used to strengthen key details (Photo courtesy PlastiComp).

FIGURE 9
The strengthening UD tapes can be seen in place (Photo courtesy PlastiComp).

market for both (See: https://www.plasticomp.com/continuous-tape-inserts-white-paper/).

LFT not only expands the market for reinforced plastics "upward" from more basic composites, but also downward. "Injection molded materials are much more three dimensional compared to a lay-up process where you are working with 2D sheets and trying to bend and shape them around a preform," Wollan says. "You are getting more performance with advanced composites in lay-up processes, but you are much more limited in geometries."

3. LFT Extrusion

"We have just done development work to prove the feasibility to use LFT in extrusion," Bowen says. "We have actually produced some parts. The benefit of LFT in extrusions is pretty much the same as in injection molding. You get stiffer, tougher profiles." Of course, you get a lot of fiber orientation in the extrusion process, but the parts become much higher impact resistant, making them suitable for lumber substitution, replacing things like wooden sticks, fencing, and construction profiles.

"In some cases, we can even replace aluminum profiles with a lighter weight composite that is also less expensive," Wollan adds. "The basic one we started with was a shovel handle."

So, the extrusions can even replace construction I-beams. "And with the extrusion process, you can also introduce UD material to clad or put in a strength member," Bowen says. "We have done that, and that capability is available for our customers to evaluate."

4. Reducing athlete and worker fatigue

The main applications for PlastiComp's long fiber thermoplastics are sports and leisure equipment, and industrial components.

They are popular in sporting gear where performance – that is light weight, high stiffness, high impact strength, high fatigue resistance... – of the gear influences the success of the athlete (Figure 10). "The market for sporting goods is very receptive to higher performance materials," Bowen explains. "In order to have something more lightweight, which fatigues the athlete less, they are willing to pay for the performance that comes with carbon fiber. That is one of the reasons why we developed our hybrid materials in which we are mixing carbon fiber with glass fiber: to allow people to adapt some carbon fiber technology with not as high a cost point."

Wollan explains that the same reasons also contribute to their materials finding more and more use in industrial equipment: "There is a big push to give tools and equipment more portability and reduce worker fatigue. So, metals are being replaced in for example fasteners, pneumatic industrial nail guns, big industrial screws, handheld drills and such." Because these applications need to be sturdy and able to support some weight, they need fiber reinforcement. And LFT parts are not only lighter weight but can withstand corrosion better than metal ones.

5. New opportunities

Are there any new markets on the horizon for LFT? "An example of an emerging market segment is 5G technology," Bowen says (Figure 11). "That may offer some new opportunities because of its higher electrical requirements. Another advantage of long fiber is not structural but electrical: if you need connecting conductive fibers for shielding or static dissipation. Those fibers could be stainless, carbon or metal-coated."

So, some parts that are now made of metal because components will interfere with each other if they are not isolated or shielded, can be replaced with thermoplastics filled with long

FIGURE 10
Long fiber thermoplastics are popular in sporting gear where the performance of the gear influences the success of the athlete, as can be seen in this bicycle suspension link (Photo courtesy PlastiComp).

FIGURE 11

The need for shielding or static dissipation in 5G technology may offer new opportunities to long, electrically conductive fiber reinforced plastics (Photo: Shayneppl stockphoto/Shutterstock).

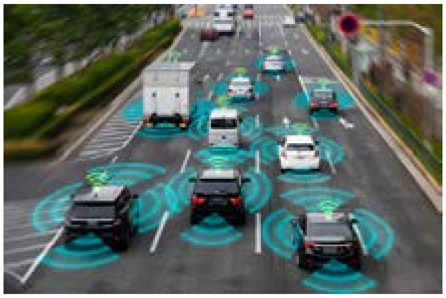


FIGURE 12

The sensors of self-driving cars need to be protected against interference from other cars, which may also offer opportunities for long, electrically conductive fiber reinforced plastics. (Photo: metamorworks/Shutterstock).

conductive fibers. Applications of that can also be found in aerospace or in self-driving cars. "The sensors of self-driving cars are little radars that need to be protected against interference from other cars and radars," Wollan explains (Figure 12).

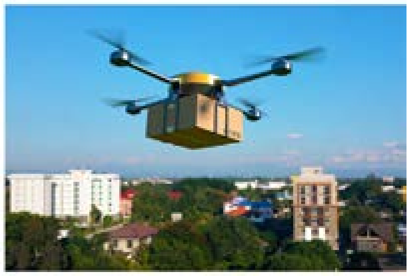
FIGURE 13

Drones are too much a fragmented industry for large scale use of long fiber reinforced thermoplastics at the moment (Photo: Tochanchai/Shutterstock).

Which of course begs the question: is drone technology going to be a growth market for LFT (Figure 13)? "That is a fragmented industry," Bowen says. "Tough to see where that is going to go. Maybe as consolidation takes place among businesses, there will be an area where there is enough momentum or volume for it to take off. Right now, there are just a lot of small players. But as it scales up, there may be potential for LFT."

"A lot of what you now see in drones is just a camera platform, like a cellphone type camera," Wollan adds (Figure 14). "That

(a)



(b)

FIGURE 14

a,b: When drones take off at a large scale, for example for package delivery, there may be potential for LFT (Photo: Tochanchai/Shutterstock and Chesky/Shutterstock).

does not have any strong structural requirements. The more heavy-duty drones, like for military applications, are lower volume. But if for example the mail service decided to start delivering all packages via drones, they would need something that has cargo capacity. When we move away from advanced composite lay-ups, long fiber injection molded composites are the next step. And then there is the spot delivery of fertilizer and pesticides in agriculture... a lot of things, but no large volumes yet."

Bowen explains that the step from lay-up technologies to injection molding is not only for lowering the price of the product: "It is more about simplifying their manufacturing, so they can produce higher volumes more easily. You can injection mold something in thirty to ninety seconds. A lay-up may take hours or days. In general, you have to consider the tooling costs though. They can be substantial enough that volumes need to get into the thousands per year for the transition to injection molding to make sense."

As new technologies reach new markets, LFT is usually not the first material of choice. But it is a key material for expanding the market of those new technologies. "We are a segue technology between short fibers and advanced composites," says Bowen.

FEATURE

Knocking tooling into shape

Liz Nickels

The industry for molding and tooling systems is moving in pace with end users' requirements for more cost-effective materials and improved finishes. Liz Nickels discussed current developments with UK-based Scott Bader.

Scott Bader, established in 1921, is a US$287 million global chemical company, employing over 700 colleagues worldwide. It was one of the first producers of unsaturated polyester resins in the early 1950s and one of the pioneers of gelcoat technology. The company also made a number of adaptations and launched new resin products in the field of urethane acrylate technology. Unusually in the composites industry, it has an employee owned business model which ensures employees are involved in key decisions, profits are shared, and a percentage of the income is given to support charitable activities and projects around the world.

Despite global economic uncertainty, Scott Bader continues to grow. In October 2018, the company created Scott Bader Japan KK, a new business based south of Tokyo in Yokohama, aimed at increasing the company's presence in the Japanese market for adhesives and composite materials, focusing on the wind energy, marine, land transportation, building and construction industry.

Today, its products include adhesives, gelcoats and resins for the composites industry. This February, at the JEC World show, it introduced Crestamould®, a new brand for their matched tooling systems, and in April the company reported how it had worked with Spanish company Castro Composites, which manufactures parts, composite molds, and CNC, to develop a wind blade mold using its tooling system. The blade was 11.6 m with a 480 kg weight with a wind turbine power of 100 kw. To produce the wind blade molds, Skillful LDA used materials supplied by Castro Composites which included Crestamould 15PA tooling gelcoat, Crystic Barriercoat, Crestamould VE679PA and Crestamould 4010PA rapid tooling resin (Figures 1 and 2).

Skillful LDA said that the benefits of using the tooling system were easier to apply materials, low shrinkage materials, no print through of fabrics, improved wettability of fabrics, improved gelcoat brightness, and no porosity (Figure 3).

I spoke to Carl Tydd, sales development manager, who, along with Deklyn Barnes, Assistant Product Manager, recently ran a webinar covering the new Crestamould system (Figure 4).

FIGURE 1

The wind turbine blade molds in production.

E-mail address: Nickels, L. (liznickelsfreelance@gmail.com)

FIGURE 2
The blade molds produced using Crestamould 15PA tooling gelcoat, Crystic barriercoat, Crestamould VE679A and Crestamould rapid tooling resin 4010PA.

FIGURE 3
Scott Bader's Crestamouldu match tooling system is used to produce molds for wind turbine blades.

FIGURE 4
Carl Tydd, Sales Development Manager at Scott Bader UK.

Carl, with a background in the solvent industry, joined the company in 2015 in a sales role and last year he progressed into the Adhesives and Tooling team.

What are the stages of the tooling and molding system?

The tooling process includes spraying or extruding a tooling compound before final machining. Once the plug is CNCed, Crestamould F24 fairing compound is applied. This material is waterproof, which means that it can be used below the water line. It also offers good adhesion to cured fiber reinforced polymer and Vinylester laminates. It sands more easily, gives a hard finish, and can be used on mold repairs too. Crestamould F26 is suitable for plugs and molds as well as repairs. Once the plug is ready, the company's primecoat can be sprayed or brushed wet on wet and then surfaced with glosscoat on top.

The mold making sequence begins with the Scott Bader's Crestamould Tooling Gelcoat, 15PA. Which is available in a range of colors. This is followed by an application of the VE679PA or VE690PA skincoats – 690 being more suitable for molds with a larger upstand. At this stage, around 300 g of chopped strand mat and tooling resin can be applied in layers.

What developments have occurred in the last ten years or so in this field?

More and more over the past few years, clients have been requesting quicker and more efficient ways of making molds. However, it always comes with other stipulations, such as higher heat deflection temperature (HDT), low shrinkage, and so on. A further demand is the ability to produce extra parts from the same mold – so durability is a hot topic.

Have you found that end users have had an increased focus on environmental issues?

Larger players in this industry have become increasingly aware of environmental issues and have become more focused on change wherever possible. For example, there has been a focus on the use of acetone and ways to replace it with a more environmentally friendly alternative. Similarly, other customers had been asking us about the sources of raw materials and their bio content. As part of the development process, the use of bio derived raw materials is playing an increasing role, and indeed, some of our customers are now insisting on this.

However, some environmental developments have been hindered by a slow start as the environmental alternatives out there do not always reach the customers' expectations. From our experience, small to medium customers are still focussed to a large extent on the cost and performance elements of our products, but there is evidence they are also becoming increasingly concerned with environmental issues such as the recycling of pails and drums, which can be easily facilitated by the use of liners.

What new markets/applications have emerged?

Outside of our partnerships in the marine industry we have also now seen an uplift of applications within automotive, land transportation and Wind. Indeed, any applications that require composites require tooling products to develop molds.

How has processing changed over the last ten years or so?

The biggest changes have been technology and introduction of CNC 5 axis machines, where previously they were solely made from timber. As well as this, composite parts are increasing in size, vehicles are getting larger (motorhomes, trucks), as are yachts. More and more composite materials are being introduced and replacing metals, leading to a reduction in weight and a lessening the environmental impact.

What are the biggest challenges facing you at the moment?

The industry is ever changing and quicker turnarounds of materials are requested by our customers. Most of the business is project lead and tend to be Just-In-Time (JIT) manufacturing, so whoever can produce the quickest gets the business.

What are the biggest sources of growth?

The wider use of composites in land transportation and the development of more energy efficient models in the marine industry are causing a big increase in the use of composite tooling.

How do you think the market for adhesives will develop over the next 10–20 years?

Adhesives are a key enabling technology for lightweighting as they allow for the joining of dissimilar materials. This allows designers to use the appropriate material for a particular application and then join the pieces together. The drive for lightweighting across many industries is driving the growth of adhesives. Scott Bader's Crestabond® Methyl methacrylate (MMA) adhesives are ideally designed for this, as they require no surface preparation and are able to bond composites, plastics and metals.

How do you think the technology will develop?

Slowly but surely, we are seeing developments in infusion resins for tooling being developed. They are becoming cleaner, more environmentally friendly, and projects can be priced more accurately as it is easier to know exactly how much material is needed.

What is unique about Scott Bader's Crestamould products?

Crestamould is a rapid tooling system with low shrinkage and low peak exotherm, so once the product reaches its peak, you can add another layer, thus creating a quicker turnaround. In principle, using a small to medium mold, it could be possible to turn one around within 24 h. Previously this may have taken over a week.

Scott Bader; www.scottbader.com

ELSEVIER

Events Diary

30 September–4 October 2019
San Sebastian, Spain
Trends in Nanotechnology 2019
Contact: Phantoms Foundation
E-mail: info@phantomsnet.net
www.tntconf.org

1–3 October 2019
Tampa, FL, USA
IBEX 2019
Contact: Anne Dunbar
Show Director
Tel: +1 716 662 4708
E-mail: anne@ibexshow.com
www.ibexshow.com

1–2 October 2019
Berlin, Germany
Pigment and Color Science Forum 2019
Contact: Smithers Rapra
Tel: +44 (0) 1939 250383
Fax: +44 (0)1939 251118
E-mail: info@rapra.net
www.pigmentmarkets.com

8–9 October 2019
Krakow, Poland
Kompozyt-Expo 2019
Contact: Targi w Krakowie Ltd
Tel: +48 12 644 59 32
Fax: +48 12 644 61 41
E-mail: kompozyty@targi.krakow.pl
www.kompozyty.krakow.pl

8–10 October 2019
Milan, Italy
Go Carbon Fibre 2019
Contact: Smithers Rapra
Tel: 01372 802000
E-mail: info@smithersrapra.com
www.gocarbonfibre.com

15–16 October 2019
Oxford, UK
Confidence in Composites
Contact: Composites UK Limited
Tel: +44 (0)1442 817502
E-mail: info@compositesuk.co.uk
www.confidenceincomposites.com

22–24 October 2019
Moscow, Russia
Testing & Control 2019
Contact: ITE Moscow
Tel: +7 (499) 750 0828
Fax: +7 (499) 750 0830
E-mail: control@ite-expo.ru
www.testing-control.ru

23–25 October 2019
Lisbon, Portugal
European Graphene Forum 2019
Contact: Dubai Studio City
Tel: +33 (0)1 48 72 88 98
Fax: +33 (0)1 48 72 88 98
E-mail: info@setcor.org
www.setcor.org

30–31 October 2019
Birmingham, UK
Advanced Engineering Birmingham 2019
Contact: Easyfairs UK Ltd
Tel: +44 (0)20 8843 8800
Fax: +44 (0)20 8892 1929
E-mail: uk@easyfairs.com
www.easyfairs.com

12–13 November 2019
London, UK
The Commercial UAV Show 2019
Contact: Terrapinn Holdings Ltd
Tel: +44 (0)20 7608 7030
Fax: +44 (0)20 7608 7040
E-mail: enquiry.uk@terrapinn.com
www.terrapinn.com/exhibition/the-commercial-uav-show

13–14 November 2019
Nantes, France
Composite Meetings 2019
Contact: abe (advanced business events)
Tel: +33 (0)1 41 86 41 60
Fax: +33 (0)1 46 04 57 61
E-mail: info@advbe.com
france.compositesmeetings.com

13–15 November 2019
Seoul, South Korea
JEC ASIA 2019
Contact: Christian Strassburger, events director, Asia
Tel: +65 90 69 91 51
E-mail: strassburger@jeccomposites.com
www.jec-asia.events

14–15 November 2019
Cologne, Germany
8TH Biocomposites Conference
Contact: nova-Institut GmbH
Tel: +49(0)2233-48-1449
E-mail: dominik.vogt@nova-institut.de
www.biocompositescc.com

20– 21 November 2019
Santa Clara, CA, USA
Graphene & 2D Materials USA 2019
Contact: IDTechEx Ltd
Tel: +44 (0) 1223 813703
Fax: +44 (0) 1223 812400
E-mail: events@IDTechEx.com
www.grapheneusa.tech

20–21 November 2019
Vienna, Austria
Composites in Building & Infrastructure Summit
Contact: Vonlanthen Events Management
Tel: +420 210 022 041
E-mail: info@vonlanthengroup.com
www.vonlanthengroup.com

20–21 November 2019
Gothenburg, Sweden
Lighter International Conference 2019
Contact: RISE IVF
Tel: +46 070-780 60 52
E-mail: info@lighterarena.se
lighterarena.se/sv/event/lighter-international-conference-2019

20–22 November 2019
Mumbai, India
World of Composites at Techtextil India
Contact: Messe Frankfurt
Tel: +91 22 61445957
Fax: +91 22 6144 5999
E-mail: info@india.messefrankfurt.com
techtextil-india.in.messefrankfurt.com

28–30 November 2019
Istanbul, Turkey
Eurasian Composites Show
Contact: Artkim Fuarcılık
Tel: +90 0212 324 00 00
Fax: +90 0212 324 37 57
E-mail: sales@artkim.com.tr
www.eurasiancomposites.com

3–5 December 2019
Cologne, Germany
Fire Resistance in Plastics 2019
Contact: Applied Market Information Ltd
Tel: +44 (0) 117 924 9442
Fax: +44 (0) 117 311 1534
E-mail: info@amiplastics.com
www.amiplastics.com/events

4–5 December 2019
Berlin, Germany
Automotive Surfaces 2019
Contact: Crain Polymer Group
Tel: +1 330 608 0231
E-mail: dhershfield@crain.com
www.decorativeautomotiveplastics.com

11–13 December 2019
Shanghai, China ANEX/SINCE 2019
Contact: UBM Asia Ltd
Tel: +852 2827 6211
Fax: +852 3749 7342
E-mail: damian.goh@ubm.com
www.asianonwovens.org

11–12 December 2019
Scottsdale, AZ, USA
American Aerospace & Defense Summit 2019
Contact: Generis Group
Tel: +1 (416) 298 7005
E-mail: info@generisgp.com
www.aadsummit.com

15–17 January 2020
Tokyo, Japan
Automotive Weight Reduction Expo 2020
Contact: Reed Exhibitions Japan Ltd
Tel: +81 (0)3 3349-8501
Fax: +81 (0)3 3349-8599
E-mail: car@reedexpo.co.jp
www.altexpo.jp

29–31 January 2020
Tokyo, Japan
NANO TECH 2020
Contact: JTB Communication Design
Tel: +81 03-5657-0759
Fax: +81 03-5657-0645
E-mail: nanotech@ics-inc.co.jp
www.nanotechexpo.jp

11–16 February 2020
Singapore, Singapore
Singapore Airshow 2020
Contact: Experia Events Pte Ltd
Tel: +65 6542 8660
Fax: +65 6546 6062
E-mail: sales@singaporeairshow.com.sg
www.singaporeairshow.com

25–27 February 2020
Nuremberg, Germany
Embedded World 2020
Contact: Weka Fachmedien GmbH
Tel: + 49 0 89/255 56 1000
E-mail: events@weka-fachmedien.de
www.events.weka-fachmedien.de/embedded-world-conference

26–28 February 2020
Lisbon, Portugal
Future Materials 2020
Contact: Yuktan Technologies Pvt Ltd
Tel: +65 9189 1271
E-mail: rishi.k@materialseurope.com
materialsconference.yuktan.com

31 March–3 April 2020
Geneva, Switzerland
INDEX 2020
Contact: Edana
Tel: +32 0 2 734 9310
Fax: +32 02 733 3518
E-mail: info@palexpo.ch
www.index17.org

31 March–1 April 2020
Manchester, UK
World Advanced Materials Summit & Expo
Contact: GB Media & Events Ltd
Tel: +44 (0) 1642 438225
E-mail: info@gbmediaevents.com
www.wamse.com

20–24 April 2020
Birmingham, UK
Mach 2020
Contact: MTA
Tel: 07825 585 864
E-mail: mach@mta.org.uk
www.machexhibition.com

28–29 April 2020
Manchester, UK
AMCONF 2020
Tel: +44 7709 181 838
E-mail: info@amconf.com
www.amconf.com

22–26 June 2020
Nantes, France
19th European Conference on Composite Materials (ECCM19)
Contact: MCI FRANCE
Tel: +33 1 53 85 82 63
Fax: +33 1 53 85 82 83
E-mail: info@eccm19.org
www.eccm19.org