ELSEVIER

REINFORCED plastics

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Image: Plastics manufacturer Lanxess says that its short glass fiber reinforced Durethan polyamide material is suitable to be used in drones. At Chinaplas 2018 in April this year, the company presented a range a drone propeller made of the material, which is resistant against aging by UV rays and therefore suitable for outdoor use.

REGULAR SECTIONS

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Applications

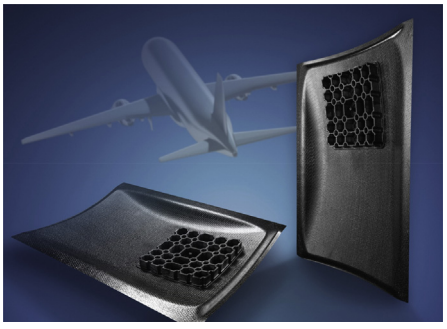
Multipurpose sandwich material

BASF says that its new polyethersulfone Ultrason E material makes it easier to make sandwich structures for airplane interiors.

The same material can reportedly be processed into different components of the sandwich structure in a single tool, helping reduce cycle times and manufacturing costs.

The sandwich consists of a foam core and carbon fiber laminates made of Ultrason E, and if required, the thermoformed foam core with cover layers can then be overmolded with carbon-fiber reinforced Ultrason E 2010 C6 to incorporate reinforcements, structures or additional functional elements into the sandwich. The combination of 30% carbon fibers with the amorphous high-temperature plastic can improve mechanical properties for the light foam sandwich over a temperature range of −100 to +200°C.

The material, has a limiting oxygen index of 38 (according to ASTM D 2863) and meets the requirements for commercial aircraft with regard to combustibility and heat release without the addition of flame retardants.



The same material can reportedly be processed into different components of the sandwich structure.

BASF; www.basf.com

0034-3617/https://doi.org/10.1016/j.repl.2018.09.007

University racing team succeeds with composite vehicle

The racing team of Yıldız Technical University, based in Istanbul, Turkey, did well in a recent student race, thanks to the use of composites material in its vehicle, according to manufacturer Kordsa.

YTU Racing Team passed all technical control stages, qualified to participate in the dynamic race stages and finished in twentieth place out of 60 teams in the Formula Student race, which aims to develop innovative young engineers possessing team spirit.

The composite materials supplied by Kordsa were used especially in the hull, wings and seats of the vehicle to make these parts stronger, more durable and more convenient for speed due to their light weight.

Kordsa; www.kordsa.com

0034-3617/https://doi.org/10.1016/j.repl.2018.09.006

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Sound reducing honeycomb tested by NASA

Hexcel says that its Acousti-Cap broadband sound-reducing honeycomb has successfully been used during a NASA-Boeing flight test on a B737 MAX test platform.

The material can attenuate a broader noise frequency range and has increased acoustic absorption due to the design of the overall inlet that reduces drag and improves noise attenuation, Hexcel says. This can enable engine designers to reduce the noise from takeoffs and landings yet without adding significant weight to the aircraft.

'Hexcel has continued investing in the evolution of Acousti-Cap product technology to improve performance and reduce cost,' said Imad Atallah, group product manager for honeycomb at Hexcel. 'Collaboration with industry leaders, including NASA and Boeing, has been key to that development.'

Hexcel; www.hexcel.com

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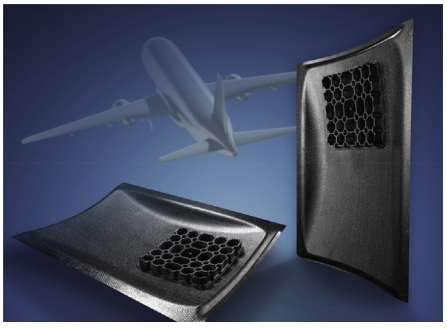

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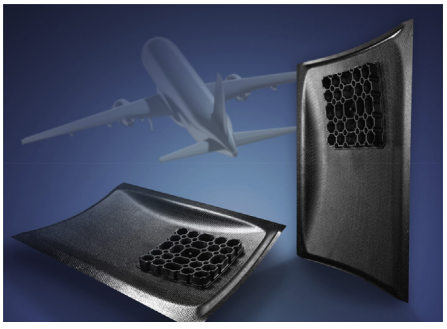

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Catamaran has infused carbon fiber sandwich structure

Materials specialist Diab says that a catamaran, launched in Norway, makes use of infusion carbon fiber sandwich technology due to its lightweight, durable properties.

Shipbuilder Brødrene Aa's new carbon fiber catamaran is called Rygerdronningen and will take tourists on sustainable sightseeing tours through the Lysefjord in Rogaland, Norway. It is 37 m long, 10 m wide and has room for 297 passengers. The sandwich panels are made using Divinycell products from H60 up to H200 in 30–60 mm thickness with vacuum infusion.

Shipbuilder Brødrene Aa's new carbon fiber catamaran will take tourists on sustainable sightseeing tours through the Lysefjord in Rogaland, Norway.

Diab has been working with Brødrene Aa since 1974 and together they have developed several ships using Divinycell fiber-reinforced panels. Compared to glass fiber sandwich and aluminum, carbon fiber provides four times the rigidity of glass fiber reinforcement, as well as two to three times the tensile strength, Diab says.

Diab; www.diab.com

0034-3617/https://doi.org/10.1016/j.repl.2018.09.004

Core composites benefit Australian fishing vessel

A new 14 m long fishing vessel designed in Australia reportedly features sandwich core composite materials from ATL Composites in co-operation with core specialist Diab.

The Barcoo Drift will be used on the Barcoo River in Queensland, Australia and was designed by Roger Hill Yacht Design, based in New Zealand.

The power catamaran was constructed using a combination of DuFLEX composite panels with Diab's Divinycell H80 and HM100 structural foam cores. Some panels were laminated with unidirectional laminates so they could be strip-planked to conform to the more compound sections of the outer topsides and wing-deck areas.

To provide extra strength while keeping the vessel light, Divinycell HM100 was engineered into the hull bottoms and lower topsides. All other structural sections including bulkheads, hull soles, cabin sides and side decks were supplied as CNC-routed DuFLEX component packs cored with Divinycell H80 in a variety of thicknesses and e-glass fiber reinforcements.

The interior fit-out was supplied as a CNC-routed component pack in Featherlight FF1015X6 Marine Grade panels from ATL Composites. The panels were cored with 15 mm Divinycell H60, a low density IPN foam.

ATL Composites makes composite materials, epoxy laminating and adhesive systems for the boatbuilding market in New Zealand and Australia and provides other industries with sandwich core composite materials. The company has a long-standing relationship with the Diab Group as distributor for its product range.

The Barcoo Drift will be used on the Barcoo River in Queensland, Australia and was designed by Roger Hill Yacht Design, based in New Zealand.

Diab; www.diab.com

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Business

Quickstep to collaborate with Triumph

Quickstep Holdings Limited, an Australian manufacturer of carbon fiber composite components, has signed a Letter of Intent (LoI) for future collaboration with Triumph Group, which makes aerospace structures, systems, and components, headquartered in the US.

The companies plan to pursue new business opportunities from customers in the US and Australian defense and aerospace markets.

'By working together, we expect to gain a mutual benefit that is greater than working independently and this will enable us to jointly offer better value solutions to our respective customers in both Australia and the US,' said Ian Reason, vice president at Triumph.

Quickstep;
www.quickstep.com.au

0034-3617/https://doi.org/10.1016/j.repl.2018.09.047

Developments in Brazilian composites

TenCate Advanced Composites, part of the Toray Group, has met with other companies to develop a regional knowledge-base in thermoplastic composite technology for the next generation of aircraft.

Partners including Embraer, Alltec, Technological Institute of Aeronautics (ITA), Instituto de Aeronáutica e Espaço (IAE), São Paulo State University (UNESP) and the Institute for Technological Research of the State of São Paulo (IPT) met to consider building a Brazilian center of excellence for thermoplastic composites through the creation of joint R&D programs and a knowledge-sharing platform.

TenCate Advanced Composites has met with other companies to develop a regional knowledge-base in thermoplastic composite technology for the next generation of aircraft.

'A fully aligned supply chain across OEMs, tiers, material suppliers and institutes is vital for the successful adoption of thermoplastic composites in aerospace,' Winand Kok, director at TenCate.

TenCate Advanced Composites;
www.tencate.com

0034-3617/https://doi.org/10.1016/j.repl.2018.09.046

UK focus on automotive composites

Project 12, a composite finishing company based in the UK, says that it has collaborated with Total Composite Solutions on automotive OEM projects for bespoke carbon parts.

TCS is the UK partner of Microtex SRL which makes the clear cosmetic prepreg prepreg used in the projecta, along with Project 12's coating and carbon fiber substrate surface structure.

'X4-160 is gaining popularity within the industry due to its clarity, dicy free resin and high TG, enabling flexibility of design application both internally and externally within the vehicle,' said Michael Stevenson, commercial director of TCS.

TCS;
www.totalcompositesolutions.com

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Solvay receives supplier award

Solvay has received a supplier excellence award from unmanned aerial vehicles manufacturer General Atomics Aeronautical Systems. Solvay supplies out-of-autoclave prepregs, adhesive films, and ancillary materials for the company's UAVs.

The GA-ASI Supplier Excellence Awards recognize suppliers who have a 100% quality and on-time delivery performance rating for calendar year 2017.

'Solvay is honored to partner with GA-ASI by supplying composite technologies for its advanced aircraft and defense systems,' said Marc Doyle, executive vice president of Solvay's composite materials business unit.

Solvay; www.solvay.com

0034-3617/https://doi.org/10.1016/j.repl.2018.09.044

Front Street Shipyard builds new facility

Front Street Shipyard, a manufacturer of composite boats based in Maine, USA, has begun construction of a new facility next to its existing yard on the waterfront. The new facility will accommodate large yacht refits and commercial vessel construction projects while adding approximately 40 more full-time job, the company said.

The new facility will be tall enough to fit the large 485-ton mobile hoist to drive boats inside, maximizing space and reportedly reducing the need for additional support equipment.

Front Street Shipyard; www.frontstreetshipyard.com

0034-3617/https://doi.org/10.1016/j.repl.2018.09.043

SGL Carbon expands aerospace business

SGL Carbon and an unnamed US aerospace company have expanded their business for the thrust reverser engine cowling blankets, SGL says. The airline's thrust reverser insulation is being replaced by SGL Carbon's insulation blankets. The contract comprises 350 blankets and will be completed by November 2018.

'In a very short time we managed to deliver the increased rates by working out plans for manpower, materials, equipment and product flow to support incremental capacity increase,' said Dr Andreas Erber, head of the aerospace at SGL Carbon.

SGL achieved Parts Manufacturing Approval (PMA) of the Federal Aviation Administration (FAA) for High Performance Insulation blankets in 2009.

SGL; www.sglcarbon.com

0034-3617/https://doi.org/10.1016/j.repl.2018.09.042

Focus on composites safety

Composites UK has put in place a three-year strategy to improve safety in plastics and composites manufacturing.

This forms part of the Safety in Manufacturing Plastics and Composites (SIMPLC) initiative which was launched in 2010. This new strategy, supported by the Health and Safety Executive (HSE), will run from 2018 to 2021 and covers trade organizations and unions in a bid to stimulate progress on accident and ill-health reduction by helping to embed a health and safety culture within businesses.

Individual companies can sign a pledge to demonstrate their commitment to improving the health and safety record of the industry as a whole. In return, SIMPLC will continue to help employers achieve what they identify as health and safety priorities for their individual business.

Participating trade associations and other supporting organisations have updated their action plans to help their members achieve long-term improvements. Accident reporting will be maintained through these organisations each year, the results of which will enable yearly reduction targets to be set.

'It is encouraging that the injury rate in the plastics industry has significantly reduced since the first strategy in 2010, and is now below the all manufacturing industries average,' said HSE head of manufacturing and utilities John Rowe. 'In line with the HSE Helping Great Britain Work Well strategy, the SIMPLC strategy for 2018–2021 aims to continue with initiatives to reduce accidents within the sector. There is also a commitment to reducing the incidence of occupational ill-health. The new SIMPLC initiative aims to continue to work with everyone across the plastics and composites industries to really drive change and reduce the number of people being injured or made ill by their work.'

Composites UK; compositesuk.co.uk

0034-3617/https://doi.org/10.1016/j.repl.2018.09.041

Polydist UK and Sabic announce broader relationship

Polydist UK says that it is now distributing Sabic's polymer resins in the UK. The products include Sabic's Noryl and Ultem resins, LNP compounds, co-polymer polycarbonate grades, and Lexan, Cycoloy and Valox flame retardant resin.

Polydist and SABIC first formed a distribution agreement in 2015 covering Sabic LDPE and LLDPE materials.

'We look forward to our broader relationship with Polydist and strengthening our business in the UK,' said Pieter Keijer, commercial director of Sabic's Specialties business.

Sabic; www.sabic.com

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Individual companies can sign a pledge to demonstrate their commitment to improving the health and safety record of the industry as a whole. In return, SIMPLC will continue to help employers achieve what they identify as health and safety priorities for their individual business.

Participating trade associations and other supporting organisations have updated their action plans to help their members achieve long-term improvements. Accident reporting will be maintained through these organisations each year, the results of which will enable yearly reduction targets to be set.

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Composites UK; compositesuk.co.uk

0034-3617/https://doi.org/10.1016/j.repl.2018.09.041

Polydist UK and Sabic announce broader relationship

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Solvay receives supplier award

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The GA-ASI Supplier Excellence Awards recognize suppliers who have a 100% quality and on-time delivery performance rating for calendar year 2017.

'Solvay is honored to partner with GA-ASI by supplying composite technologies for its advanced aircraft and defense systems,' said Marc Doyle, executive vice president of Solvay's composite materials business unit.

Solvay; www.solvay.com

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Front Street Shipyard builds new facility

Front Street Shipyard, a manufacturer of composite boats based in Maine, USA, has begun construction of a new facility next to its existing yard on the waterfront. The new facility will accommodate large yacht refits and commercial vessel construction projects while adding approximately 40 more full-time job, the company said.

The new facility will be tall enough to fit the large 485-ton mobile hoist to drive boats inside, maximizing space and reportedly reducing the need for additional support equipment.

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SGL Carbon expands aerospace business

SGL Carbon and an unnamed US aerospace company have expanded their business for the thrust reverser engine cowling blankets, SGL says. The airline's thrust reverser insulation is being replaced by SGL Carbon's insulation blankets. The contract comprises 350 blankets and will be completed by November 2018.

'In a very short time we managed to deliver the increased rates by working out plans for manpower, materials, equipment and product flow to support incremental capacity increase,' said Dr Andreas Erber, head of the aerospace at SGL Carbon.

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Composites UK, Scott Bader and environment consultancy Renuables, have put together a new report covering how to best dispose of or recycle of waste fiber reinforced polymer material (FRP) in the UK.

The aim of the report is to direct research and development spending and commercial investment to develop the most environmentally and economically sustainable solutions. It will mainly focus on glass fiber reinforced polymer (GFRP), which uses a thermoset resin. It may also be relevant to thermoset carbon fiber reinforced polymer (CFRP) which is currently uneconomical to recycle by pyrolysis, the organizations say.

Composites UK has put together a new report covering how to best dispose of or recycle of waste fiber reinforced polymer material.

'Composites have an important role in the drive to reduce greenhouse gas emissions and to lessen our reliance on fossil fuel,' said Jean-Claude Pierre, CEO of Scott Bader Company Ltd. 'However, composites can never be truly sustainable until we have suitable options for their end-of-life management.'

A summary of the study is available for download on the Composites UK website.

Composites UK; www.compositesuk.com

0034-3617/https://doi.org/10.1016/j.repl.2018.09.038

Quickstep wins new defence project

Quickstep Holdings Limited, an Australian manufacturer of carbon fiber composite components, has reportedly receive funding to produce housings for an F-35 Lightning II countermeasure flare.

The F-35 Lightning II Program is the world's largest military aerospace program and the project will be funded via materials developer Chemring Australia from the F-35 Lightning II Joint Program Office, through a multi-million dollar US Government contract.

During the project, Quickstep will commission additional manufacturing processes and technologies, aiming at extending its capability to support the F-35 Program and other defence and aerospace projects.

'This exciting new project will involve Quickstep applying advanced tooling and process engineering skills to establish world-class advanced manufacturing capabilities for production of F-35 countermeasure flare housings,' sad Mark Burgess, CEO and MD of Quickstep.

Quickstep Holdings; www.quickstep.com.au

0034-3617/https://doi.org/10.1016/j.repl.2018.09.037

Extension to Quickstep agreement

Quickstep Holdings Limited, which makes advanced carbon fiber composites, has signed a Memorandum of Understanding (MoU) with Lockheed Martin for a long term flexible contract to supply wing flaps for an additional five years, covering the period 2020–2024.

Quickstep has an existing contract with Lockheed Martin to provide wing flaps for the C-130J/LM-100J aircraft through to end-2019, and this contract extension will continue the supply chain relationship.

'We are proud to be a supplier to Lockheed Martin on this critical global program and this contract extension secures the C-130J/LM-100J line of business through 2024,' said Quickstep's chief executive officer and managing director, Mark Burgess. 'In addition to this MoU, we look forward to further increasing the scope of our supply on the C-130J/LM-100J platform.'

Quickstep says that over the next three years it expects to benefit from increasing production volumes with its F-35 Joint Strike Fighter (JSF) composite parts contract and new business from Boeing Defense and Chemring.

Quickstep; www.quickstep.com.au

0034-3617/https://doi.org/10.1016/j.repl.2018.09.036

Quickstep sales up 14%

Quickstep Holdings Limited, an Australian manufacturer of carbon fiber composite components, has announced total sales of AUS$59.0 million for 2018, up 13.7% from AUS$51.9 million in FY17.

Earnings before interest, tax and research and development costs were AUS $2.4 million for the financial year ended 30 June 2018, compared to an operating loss before R&D of AUS$0.2 million for the previous corresponding year.

The group said that it anticipates its business to continue to improve in 2019 with expected revenue growth of at least 20% in 2019. It plans to win additional business in defense and aerospace.

Quickstep Holdings;
www.quickstep.com.au

0034-3617/https://doi.org/10.1016/j.repl.2018.09.035

Owens Corning appoints new COO

Glass fiber specialist Owens Corning has appointed Brian Chambers as president and COO.

'The creation of a chief operating officer and the appointment of Brian Chambers will create additional senior management capacity to accelerate our progress on growing the company,' said Mike Thaman, chairman and CEO.

Chambers has been president of Owens Corning's roofing business since 2014. Under his leadership, revenues for the roofing business grew 16% in 2017.

Gunner Smith will succeed Chambers in this role. Smith has been with Owens Corning since 2008 and has served in his current role, as vice president of sales, roofing, since 2013.

Owens Corning;
www.owenscorning.com

0034-3617/https://doi.org/10.1016/j.repl.2018.09.034

Logistics help for composite companies

Composites UK has partnered with logistics company SITE Event Logistics to help its members transport exhibition stand equipment and products to shows around the world.

'As the UK composites industry has grown we've seen an increase in our members participating in more conferences and exhibitions overseas,' said Claire Whysall, communications manager at Composites UK. 'We have formed this partnership with SITE to support them with the logistics of getting their stand equipment and products to where they need to go safely.'

Composites UK;
compositesuk.co.uk

0034-3617/https://doi.org/10.1016/j.repl.2018.09.033

Kordsa receives two global awards

Kordsa says that it has been ranked 18 in a list of 150 Brazilian employers by the Great Place to Work Institute (GPTW).

The company was previously listed as the 25th best company in 2016 and the 31st in 2017.

The company has also received the 'Best in Internship Practices' award for the third year in a row.

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Kordsa increases composites segment

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'This new step will ensure us to be a strategic supplier of key players in aerospace and civil aviation, particularly Boeing and Toray Composites Materials America Inc,' said Kordsa CEO Ali Çalı kan. 'With this acquisition, we also aim to strengthen our strong global leadership in reinforcement technologies.'

Kordsa;
www.kordsa.com

0034-3617/https://doi.org/10.1016/j.repl.2018.09.031

Kordsa among top textile patent companies

Kordsa says that it is among the top 10 companies in the world with the number of patents issued in industrial textiles as of 2018.

This follows a record number of patent applications in 2017. The company current has 174 inventions, 717 patent applications and 218 approved patents worldwide as of July 2018.

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www.kordsa.com

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Kordsa CEO Ali Çalışkan.

0034-3617/https://doi.org/10.1016/j.repl.2018.09.029

Consortium to focus on high volume production

A new consortium including companies Premium Aerotec, Faurecia and Solvay and textile institute ITA-Augsburg has launched the three-year IRG CosiMo (Industry Research Group: Composites for Sustainable Mobility), the industry's first private consortium focused on developing high volume production of thermoplastic composites for aerospace and automotive.

A new consortium has launched a three-year research group.

Premium Aerotec, Faurecia Clean Mobility and ITA Augsburg are also part of a public sponsored consortium (CC4.0 CosiMo) aimed at developing new materials and processes for in-situ polymerization of caprolactam to polyamide 6 for high volume applications in automotive.

Solvay; www.solvay.com

0034-3617/https://doi.org/10.1016/j.repl.2018.09.028

UK composite manufacturers focus on health and safety

Composites UK says that its members have supported its recently launched 2018 – 2021 Safety in Manufacturing Plastics and Composites strategy (SIMPLC).

SIMPLC aims to progress accident and ill-health reduction by helping to embed a health and safety culture within composite businesses.

Organization members are encouraged to implement a health and safety management system that is appropriate for their size of organisation and nature of business.

'Here at Tufcot we are very keen to support the SIMPLC strategy,' said David Green, Quality/H&S Manager at Tufcot Composites, which has backed the strategy. 'The composites industry is growing and innovating into new materials and processes, nevertheless all companies are likely to face the same or similar H&S issues. We have seen from failings in other sectors how important it is to take an industry wide approach to these issues, not only to protect our workforces but also our reputations.'

Tufcot Engineering's Sheffield facilities. (Photo courtesy Tufcot.)

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0034-3617/https://doi.org/10.1016/j.repl.2018.09.027

Gurit official supplier for America's Cup

Composites specialist Gurit says that it has become an official supplier to Emirates Team New Zealand's 36th America's Cup defence campaign.

A full range of composite materials, including Gurit's carbon fiber prepregs and structural core materials for the marine industry, as well as related equipment will be supplied for the build of the AC75 class yachts to be used by Emirates Team New Zealand.

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0034-3617/https://doi.org/10.1016/j.repl.2018.09.028

UK composite manufacturers focus on health and safety

Composites UK says that its members have supported its recently launched 2018 – 2021 Safety in Manufacturing Plastics and Composites strategy (SIMPLC).

SIMPLC aims to progress accident and ill-health reduction by helping to embed a health and safety culture within composite businesses.

Organization members are encouraged to implement a health and safety management system that is appropriate for their size of organisation and nature of business.

'Here at Tufcot we are very keen to support the SIMPLC strategy,' said David Green, Quality/H&S Manager at Tufcot Composites, which has backed the strategy. 'The composites industry is growing and innovating into new materials and processes, nevertheless all companies are likely to face the same or similar H&S issues. We have seen from failings in other sectors how important it is to take an industry wide approach to these issues, not only to protect our workforces but also our reputations.'

Tufcot Engineering's Sheffield facilities. (Photo courtesy Tufcot.)

Composites UK; www.compositesuk.com

0034-3617/https://doi.org/10.1016/j.repl.2018.09.027

Gurit official supplier for America's Cup

Composites specialist Gurit says that it has become an official supplier to Emirates Team New Zealand's 36th America's Cup defence campaign.

A full range of composite materials, including Gurit's carbon fiber prepregs and structural core materials for the marine industry, as well as related equipment will be supplied for the build of the AC75 class yachts to be used by Emirates Team New Zealand.

This includes Emirates Team New Zealand yachts used for preliminary regattas scheduled to be held in 2019 and 2020, including the America's Cup World Series and the America's Cup Christmas Race, as well as Emirates Team New Zealand yachts for the PRADA Cup Challenger Series and the 36th America's Cup presented by Prada.

'The range of additional products and support offered by Gurit staff is a crucial part of the complex boatbuilding tasks which lie ahead for Emirates Team New Zealand as materials, engineering and boatbuilding timelines are pushed to the limit,' said Geoff Senior, Emirates Team New Zealand construction manager.

Gurit; www.gurit.com

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Gurit reports 2018 net sales

Gurit says that it received net sales of CHF195.3 million for the first six months of 2018, a growth of 11.5%.

The company's composite materials business unit achieved net sales of CHF102.8 million in the first half-year 2018, compared to CHF104.2 million, a decrease of 1.3%. Sales to the wind energy industry declined by 10.2% to CHF62.1 million in the first six months of 2018 compared to CHF69.1 million, due to ongoing weak wind material demand in the wind energy markets in India and China which could not be fully compensated by the demand in Europe and good growth in North America, Gurit said.

In the aerospace business unit, sales decreased by 2.2% to CHF 25.0 million in the first six months of 2018 compared to net sales of CHF 25.5 million in the first half-year 2017, while Gurit's composite components business unit reported net sales of CHF 7.3 million for the first half-year 2018, a decrease of 25.4% over net sales of CHF 9.8 million generated in the first half-year 2017.

In Gurit's tooling business unit, however, net sales of wind turbine blade molds and related equipment increased by 68.9% to CHF 60.2 million compared to CHF 35.6 million in the first half-year 2017.

Gurit; www.gurit.com

0034-3617/https://doi.org/10.1016/j.repl.2018.09.025

Gurit to sell PVC business

Gurit says that it has reached an agreement with Qingdao Zhengyu Sunshine Industrial Co Ltd to sell Gurit's PVC production company in Qingdao, China for an undisclosed sales price.

This reportedly follows the company's decision to focus core materials manufacturing for the Asia-Pacific region on styrene acrylonitrile (SAN), polyethylene terephthalate (PET) and balsa wood at Gurit's existing production facility in Tianjin, China.

The transaction comprises Gurit's Qingdao operations, including its staff, PVC operating assets and product IP.

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Exel reports increase in operating profit

Exel says that in its recent half year financial report, order intake increased by 7% to €25.0 million, compared to €23.4 million in the same period last year.

Revenue increased by 9.2% to €25.3 million and adjusted operating profit was €2.0 million, representing 7.8% of revenue.

'Exel Composites reiterates its outlook for 2018 published on 23 April 2018 and expects revenue to increase significantly and adjusted operating profit to increase in 2018 compared to 2017,' said president and CEO, Riku Kytömäki. 'Group revenue increased clearly in the first half of 2018 and consequently adjusted operating profit improved. [...] The acquisitions of Nanjing Jianhui and DSC have been important milestones as we have continued to execute on our growth strategy. Nanjing Jianhui has exceeded our expectations with strong revenue growth and good profitability. We are also convinced that the acquisition of an operating composites company was the most efficient way for Exel to create a foothold in the strategically important American composites market. [...]

The integration process of DSC is well under way and is progressing according to plan.'

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Covestro upgrades sustainability grade

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MSCI evaluates companies annually according to environmental social and corporate governance standards. Covestro says that it has integrated the sustainable development goals of the United Nations into its strategy. By 2025 80% of research and development project expenses will be targeted in areas that contribute to achieving these goals the company claims.

Convestro also says that by 2025, greenhouse gas emissions per metric ton of product manufactured will be cut by half, from 2005 figures.

Covestro; www.covestro.com

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BASF extends Europe distribution

BASF says that it has strengthened its collaboration with distributor Gustav Grolman GmbH with regards to its amine-based curing agents for epoxy resin processing. Grolman plans to expand its marketing of the BASF chemicals to Italy, Spain and Portugal for use in epoxy resin-based applications such as thermosetting laminates and composite materials. The products can be used in the construction industry as well as in the automotive, marine, aerospace and industrial applications manufacturing.

The companies have worked together since 2015 in Europe.

BASF; www.basf.com

0034-3617/https://doi.org/10.1016/j.repl.2018.09.021

ASM International upgrades materials information

Materials association ASM International has upgraded its materials information digital databases, using materials information technology platform Granta MI Version 11 and the Granta MI:Explore app. The upgrade will reportedly help streamline the database and make it easier to access updated, peer-reviewed, and information on a variety of materials science information databases.

ASM has also added and updated over 14,500 records across the nine ASM digital databases.

'Our members have told us they desire a streamlined way to access ASM's depth of content and requested improvements to the interface of our Materials Information Online (MIO) offering,' said Ron Aderhold, ASM's chief operations and information officer.

ASM; www.asminternational.org

0034-3617/https://doi.org/10.1016/j.repl.2018.09.020

AOC and Aliancys form global composites company

Resins companies AOC and Aliancys have merged to form a new combined company, which will be named AOC Aliancys.

The merger follows CVC Capital Partners Fund VI (CVC) announced intent to acquire the Alpha Corporation, AOC's parent company. Aliancys has been a part of CVC's portfolio since 2015.

Joe Salley, previously CEO of Milliken and formerly operating partner at Arsenal Capital, will be the CEO of AOC Aliancys, while Fred Norman, previously CEO of AOC, will serve as CEO for the Americas and Bert Bakker, previously CEO of Aliancys, will serve as the CEO for Europe and Asia.

'This is the most important step we can take towards advancing the use of composites worldwide,' said Joe Salley. 'Merging our companies allows us to leverage our geography and technology to strengthen our shared leadership in this growing industry.'

Aliancys; www.aliancys.com

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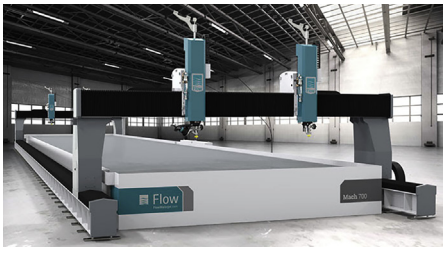
ELSEVIER

Technology

Grant for cutting machine

The US Department of Transportation has reportedly awarded over US$660,000 to composite boat maker Front Street Shipyard.

The company says that it plans to use the funds toward a purchase of a Flow Mach 700 Waterjet Cutting Machine. The equipment is designed to help streamline the construction of custom and production vessels and will be the largest of its kind in the state of Maine.



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'With a machine of this size and capability we hope to attract diverse projects, including non-marine applications,' said JB Turner, president.

Front Street Shipyard will begin installation and operation of the waterjet cutting machine early this in winter 2018.

Front Street Shipyard; **www.frontstreetshipyard.com**

0034-3617/https://doi.org/10.1016/j.repl.2018.09.018

Sabic launches GF heavy-duty panels

Chemicals company Sabic has launched a glass fiber reinforced plastic panel for the building and construction industry.

The Stadeck panel is said to be lightweight and heavy-duty, making it suitable for a range of construction applications and building techniques.

The panel also has weather and chemical resistance, anti-slip properties and improved fire behavior. Stadeck panels are NEN-EN 12811-1 certified which makes them suitable for scaffolding applications.

When compared to standard wooden planks, the panels have improved recyclability and weight savings, which can be up to 60%.

The new panels are suitable for scaffolding, frame works decking, fencing, floodwalls, jetties, sheathing, and wheel chair ramps. Stadeck panels is also are also suitable for temporary applications such as flooring at events and festivals.

The panels can be produced in different colors such as wood, stone and grass variated colors – and come in gauge 55 mm; width 230 mm and lengths of 3000 mm and 6000 mm, while customised lengths are also available.


The Stadeck panel is said to be lightweight and heavy-duty.

Sabic; www.sabic.com

0034-3617/https://doi.org/10.1016/j.repl.2018.09.017

New winding machine for small production

Roth Composite Machinery has developed a new filament winding machine, a standardized version of a gantry-type filament winding machine.

The Type 1-ECO machine is suitable for small series as well as manual production processes for applications comprising a low product complexity or for the entry into the field of filament winding technology. It is equipped with all basic functions and has a modular concept of up to four spindles and a maximum of four winding

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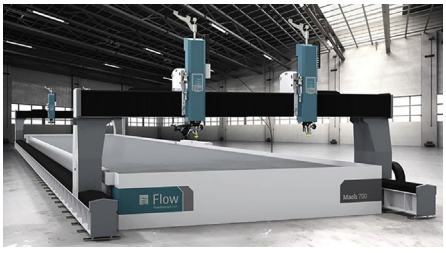

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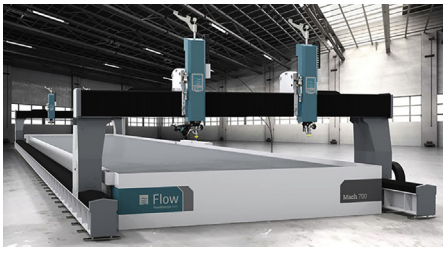

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The company says that production lines using its composite machinery have shorter installation times and help ensure a fast start of the production.

Roth Composite Machinery: www.roth-industries.de

0034-3617/https://doi.org/10.1016/j.repl.2018.09.016

The newly developed filament winding machine.

Standard safety controls on high speed dispersers

Mixing company Charles Ross says that its high speed dispersers now feature two-hand safety controls for raising and lowering the mixing head. The two-hand system requires two push buttons to be pressed and maintained to allow operation of the hydraulic lift, ensuring the operator's hands are clear from contact with moving parts.

The dispersers are used primarily for incorporating powders into liquid and can run at top speeds of up to around 5000 ft/min.

Charles Ross; www.mixers.com

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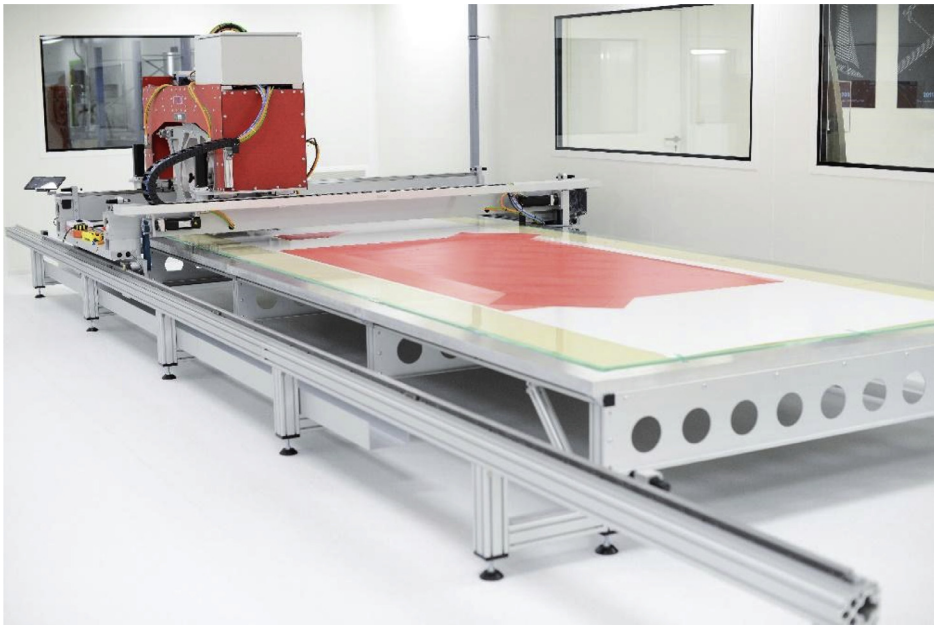
NTPT opens new cleanroom production facility

Prepreg specialist NTPT has opened new laboratory facilities and a 300 m^2 cleanroom production area at its headquarters in Renens, Switzerland. This development is part of the company's collaboration with watchmaker GMV-Richard Mille and includes the exclusive supply of NTPT's Thin Ply materials for horology, jewellery and writing instrument designs.

According to the company, the production facility is designed to make quartz and other non-carbon fiber materials and features antistatic bars, a suction unit and a new creel system, to prevent contamination and to ensure optimum quality output. A new 1 m^3 autoclave has a maximum pressure of 10 bars and maximum temperature of 260 °C. The facility can reportedly produce 7500 km of fiber and more than 7 tonnes of Thin Ply composites annually.

The R&D equipment includes differential scanning calorimetry (DSC), dynamic mechanical thermal analysis (DMTA), viscometer, microscopes, and an instron mechanical bench test.



The automated tape laying machine for the manufacture of composite preforms.

NTPT says that the cleanroom could also be used for other applications that require a high level of contamination-free composite material.

NTPT; www.thinplytechnology.com

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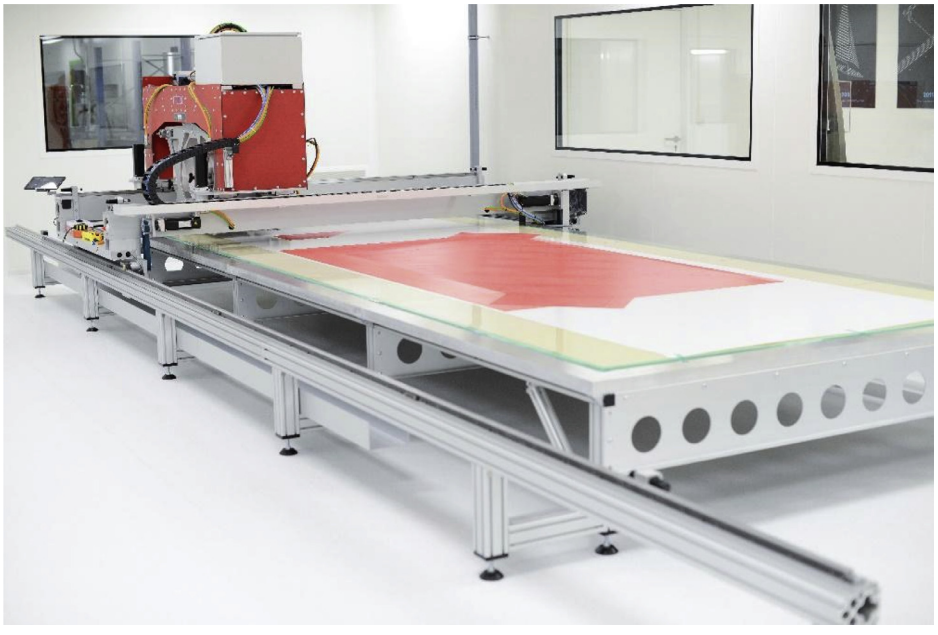

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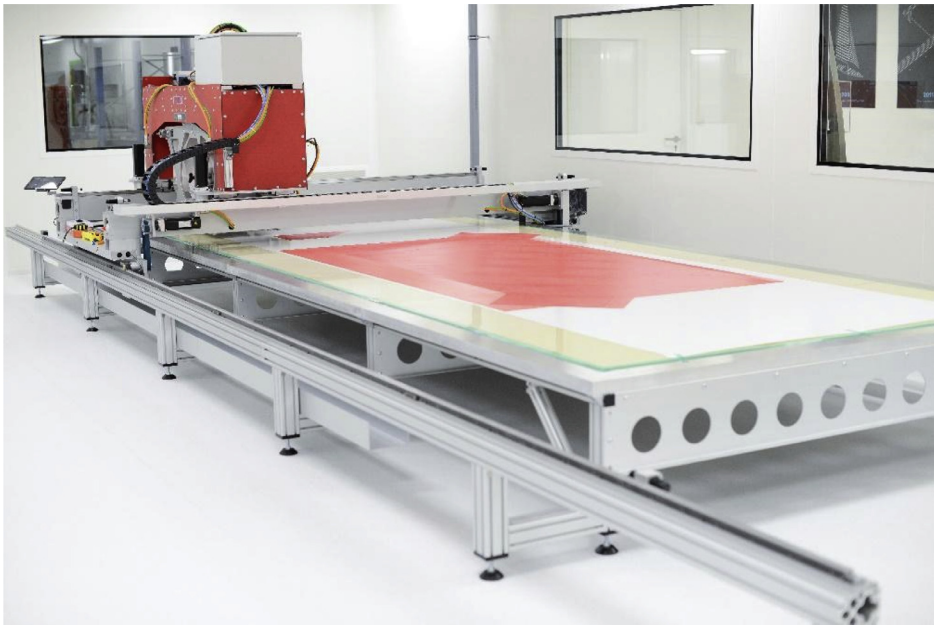

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The company says that the module can deliver almost 40% greater payload and is suitable for energy intensive industries converting to natural gas, virtual interconnects, gas islands, vehicle refueling, and transporting industrial gases.

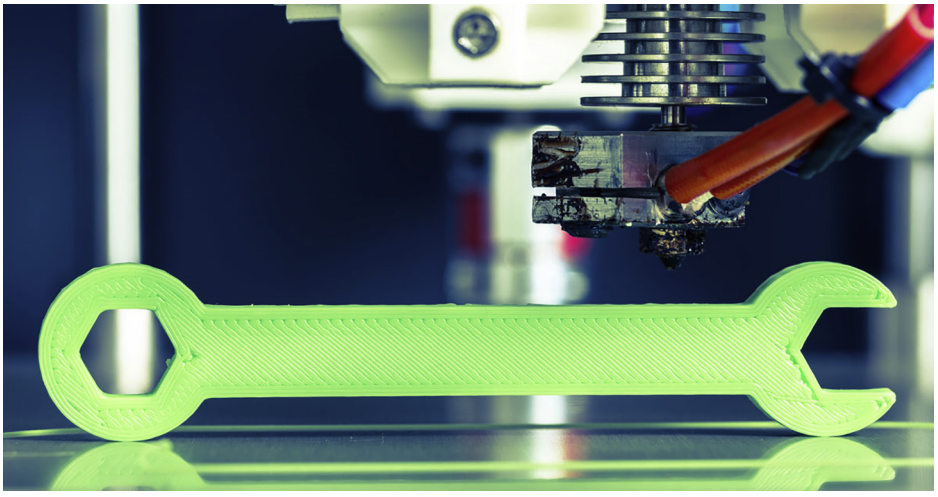
Hexagon Composites; www.hexagon.no

0034-3617/https://doi.org/10.1016/j.repl.2018.09.013

Industrial fiber printing

Research institutes the Fraunhofer Institute for Microstructure of Materials and Systems and Brightlands Materials Center plan to jointly improve fiber-reinforced thermoplastics to make them more suitable for 3D printing on an industrial scale.

3D print polymeric materials can lead to lightweight products, a more flexible design and the opportunity to integrate sensors. Fraunhofer IMWS and Brightlands Materials Center want to combine the advantages of individual production by means of 3D printing and the properties of fiber-reinforced thermoplastic materials. The partners aim to develop a better understanding of the manufacturing process in 3D printing, for example, the question of how the reinforcing fibers are embedded in the matrix and how this affects the properties of the printed composite part, such as stiffness or tensile strength. In the next step, the partners intend to develop materials and technologies to make more resilient and tailor-made components such as spare parts for automotive, aerospace and construction industries.



Components made of fiber-reinforced plastics produced by 3D printing are the focus of the joint project.

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Fraunhofer Institute; www.imws.fraunhofer.de

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Covestro introduces new name for thermoplastic composites

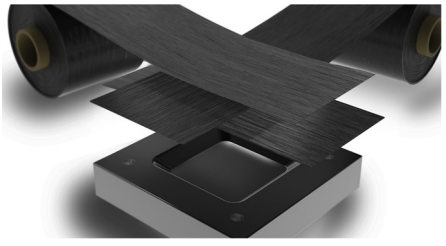
Covestro says that its continuous fiber-reinforced thermoplastic composites (CFRTP) are now branded Maezio.

Covestro produces uni-directional reinforced tapes and sheets based on continuous carbon or glass fibers impregnated with polycarbonate, thermoplastic polyurethane (TPU) or other thermoplastic resins. They can be thermoformed with existing thermoforming tools at high yield rates and low cycle times. Other production technologies such as hybrid injection molding, automated UD tape laying and automated fiber placement can also be integrated.

Maezio products can also be recycled at the end of their life.

Covestro; www.convestro.com

0034-3617/https://doi.org/10.1016/j.repl.2018.09.011



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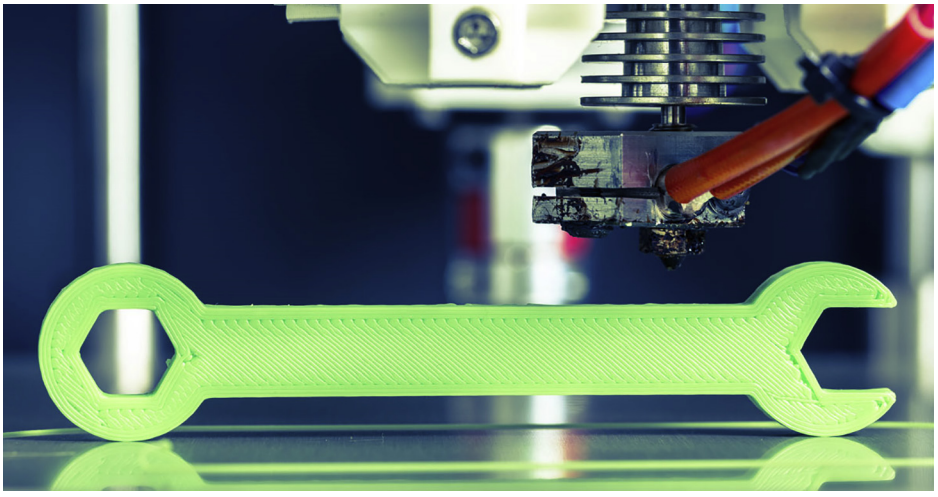

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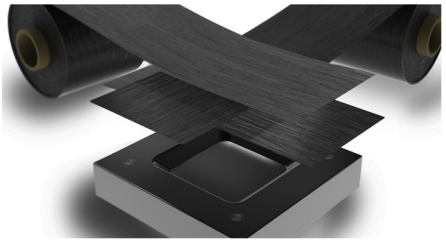

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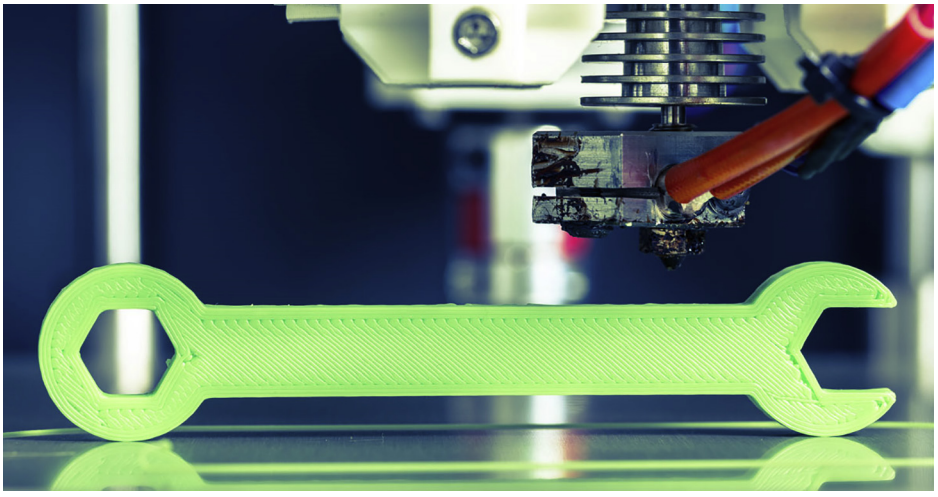

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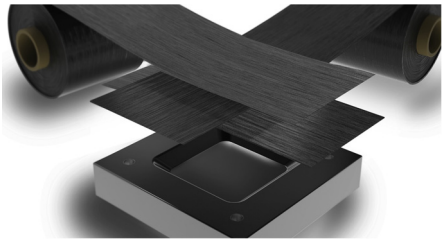

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Aachen University installs new molding system

RWTH Aachen University's Center for Integrative Lightweight Production (AZL), Germany, has reportedly installed a new injection molding system in its technical center made by Engel Deutschland GmbH in cooperation with the Engel Centre for Lightweight Composite Technologies in Austria.

The system will be used to develop new fiber-reinforced plastics (FRP) processes and improve efficiency in lightweight production. The research will address multi-material systems, continuous processes, process chains and self-optimizing processes.

'The system will expand our existing machinery in the AZL Technical Center and will be available as an important platform for lightweight production research at RWTH Aachen University,' said Dr Michael Emonts, managing director of the center.

The AZL Technical Center offers large-scale equipment for the development of processes for lightweight production, such as a composite press from Schuler Pressen GmbH with a 18,000 kN clamping force.

From left to right: Dr Norbert Müller, head of the Engel Technology Centre for Lightweight Composites, Dr Michael Emonts, managing director of the Aachen Center, Rolf Saß, general manager of Engel Deutschland GmbH and Dr Christoph Steger chief sales officer at Engel Holding. (Photo courtesy Engel Austria.)

AZL; www.azl.rwth-aachen.de

0034-3617/https://doi.org/10.1016/j.repl.2018.09.010

ELSEVIER

FEATURE

Strengthening the 3D printing composites field

Liz Nickels

3D printed plastic composites is one of the growth markets of the innovative new technology also known as additive manufacturing (AM). Liz Nickels reviewed recent developments in the field.

The Lehvoss Group, of which Lehvoss North America is a member, and its parent company Lehmann&Voss&Co of Hamburg, Germany, was founded in 1894 as a trading firm for chemical and mineral specialties.

This April the company opened a new €4.5 million laboratory and pilot plant building in Hamburg. The completion and occupation of the new premises is planned for the 1st quarter of 2019.

'By constructing the new laboratory and pilot plant building, we are aiming to ensure that we can retain and continue expanding our leading position in the field of plastics (compounds, 3D printing, masterbatches and composites) but also in raw materials for rubber as well as for paint and varnish,' said managing partner Dr Thomas Oehmichen.

Process development

Lehvoss recently partnered with Italian boat builder, Livrea Yacht, to build what it says is the world's first 3D printed sailboat. Since work began on the design in 2014, Lehvoss Group has supported the process development and engineered its Luvocom 3F customized 3D printing materials specifically for the application.

The yacht, called the Mini 650, is the project of two Italian boat builders, Francesco Belvisi and Daniele Cevola, who are building it for the 2019 solo transatlantic yacht race, called the Mini-Transat, which starts in France and ends in Brazil. Livrea Yacht performed all simulation and evaluation work for the project.

Along with their work of designing and building the Mini 650, the two boat builders have helped develop a direct extrusion 3D printing technology with their company, Ocore, which is providing the required quality of parts for the yacht. Besides improving the printing hardware of robot, extruder and nozzle – they have patented a new material deposition strategy using an algorithm inspired by fractals.

Based in Palermo, Italy, Ocore is a start-up focused on the development of new production methods to overcome the problems of traditional 3D printing using improved software, which can help ensure better integrated and more sustainable products.

None of this would be possible without a composite material especially designed for 3D printing, and Lehvoss supplied customized 3D printing materials based on high performance thermoplastic polymers.

Layer strength

'To achieve the required mechanical properties, these polymers are reinforced with carbon fibers,' said Thiago Medeiros Araujo, Luvocom 3F market development manager for Lehvoss Group. 'In addition, they are modified to yield an improved layer strength with no warping of the printed parts. This results in parts that are stronger, lighter and more durable.'

'The yacht will be highly competitive thanks to the light and strong 3D printed parts,' said Belvisi who is also the chief technology officer of Ocore. '3D printing dramatically reduces the build time for the yacht and also makes it more economical. We are looking forward not only to building the first 3D printed boat but also to winning the competition in 2019.'

'We are happy to be a partner in this challenging and very exciting project,' added Araujo. 'The Livrea yacht will show what today's dedicated processing and 3D printing polymers can already achieve.'

The Luvocom 3F product line has been designed for extrusion-based 3D printing – fused filament fabrication (FFF) and used deposition modeling (FDM). While pellets are the company's main product, filaments are available from its partners. The company has a number of 3D printing labs that cover all machine types available on the market – from small desktop printers to industrial scale machines, including a high-

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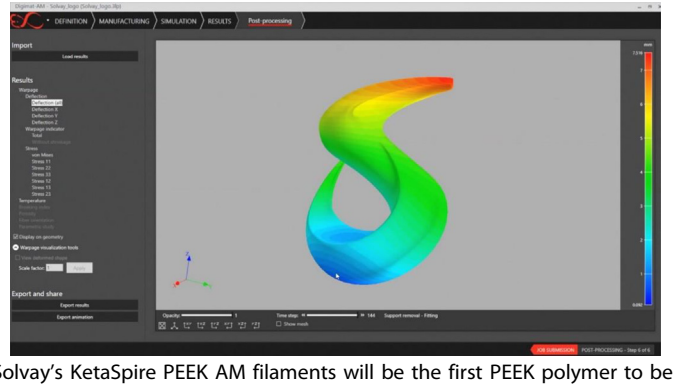
temperature machine. It is also equipped with a filament extruder and post processing devices.

The Luvocom 3F product line has been designed for extrusion-based 3D printing – fused filament fabrication (FFF) and used deposition modeling (FDM).

Of the 3F range, Luvocom 3F PEEK 9710 BK is a carbon-fiber reinforced polyether ether ketone (PEEK) grade, while Luvocom 3F PAHT 9742 CF is a carbon-fiber reinforced high-temperature polyamide. Lehvoss says that Luvocom 3F PET CF 9780 BK, based on a polyethylene therephthalate material, is the easiest carbon fiber filled material to print on the market because there are reportedly no issues with retraction and no need for a heating chamber. It has an improved surface finish straight from the printer, thus reducing the need for post-processing but it can be post-treated to improve its mechanical properties.



Solvay's KetaSpire PEEK AM filaments will be the first PEEK polymer to be modeled on e Xstream engineering's Digimat simulation software.

Leadership role

Chemicals company Solvay was established in 1863 following the invention of an ammonia-soda process set up by Ernest Solvay and a small circle of relatives including his brother Alfred. After some years of technical uncertainties, Solvay embarked on a rapid international expansion, building plants in the whole industrialized world. In 1900, 95% of the soda ash consumed in the world was produced using the Solvay process.

In October 2016, the company announced that it planned to take a 'leadership role' in aligning its polymers and engineering plastics with the fast-growing trend toward AM technologies.

According to Solvay, 3D printed composites can help reduce the weight of cars and planes and therefore CO2 emissions and also allow for more design flexibility, thereby lowering waste.

Building on the company's AM technical center and production facility for Sinterline Technyl in Lyon, France, Solvay opened a new laboratory at its Research & Innovation Center in Alpharetta, Georgia, USA, to continue to develop materials for AM. In addition to this, Solvay built a facility at its campus in Brussels, Belgium to focus on AM software design and development powered by Digimat from e-Xstream, an MSC Software company.

Digimat for Additive Manufacturing helps designers and engineers to predict warpage and the residual stresses of 3D printed parts made using Solvay's KetaSpire PEEK material as a function of AM processes, such as FFF.

'KetaSpire PEEK's inclusion in Digimat represents Solvay's latest step toward becoming the industry's leading resource for successfully applying advanced polymers in 3D printing processes,' said Christophe Schramm, business manager for AM at Solvay. 'Solvay's new AM filaments signal an important convergence between AM and specialty polymers technology, which is needed to deliver on the promise of high-end 3D printing.'

'AM has emerged as a complementary plastics conversion technology of its own right and is increasingly advancing the particular needs of highly complex parts not possible through conventional melt processes,' said Brian Alexander, head of additive manufacturing for Solvay's specialty polymers global business unit. 'As the processes and equipment develop, there is still a lack of reliable high-performance materials sourcing and standardization.'

Reduce waste

According to the company, AM processes can improve productivity by converting digital designs into functional parts for low to medium volume production without the time or cost required to first build a molding tool and prototype. AM also reportedly reduces production waste, improves the supply chain, eliminates tooling and speeds the time to market for new designs. 'It lends itself to a revolutionary democratization of manufacturing through digitization and file, rather than part transfer,' Solvay said in a press release.

The company has contributed to a 3D printed part for the Polimotor 2 all-plastic engine, designed and developed by industry pioneer Matti Holtzberg, which aims to leverage advanced polymer technology to develop a four-cylinder, double-overhead cam engine which could weigh aroundly 40 kg less than current standard production engines. The part is a plenum chamber, 3D printed by selective laser sintering (SLS) using Solvay's Sinterline Technyl polyamide 6 (PA6) powder grade reinforced with a 40% loading of glass beads.

Sinterline Technyl polyamide 6 (PA6) reportedly exhibits higher stiffness and thermal resistance than PA11 or PA12. It is available in neat and glass-bead filled grades, suitable for use in SLS applications including automotive, transportation, construction, sporting goods, appliances and electrical markets.

Design potential

Solvay also conducted studies of how AM might extend its value beyond prototype parts. Among these studies was a comparative evaluation of the tensile properties of samples that were 3D printed and injection molded from KetaSpire KT-820 PEEK. According to the company, the outcome of the first evaluation suggested the 3D printed parts will be able to meet the demanding performance requirements for these applications even at elevated temperatures seen on an engine. Solvay plans to continue evaluating the comparative performance of printed and molded PEEK parts

'A recent study of the plenum for the Polimotor 2 project confirmed that AM offers a significant, yet grossly under-utilized potential for light-weighting and complex design, even beyond the scope of injection molding,' said Dominique Giannotta, Sinterline program leader for Solvay's engineering plastics business unit. 'However, to fully take advantage of this powerful potential, industrial designers must begin to conceive parts for AM from day one.'

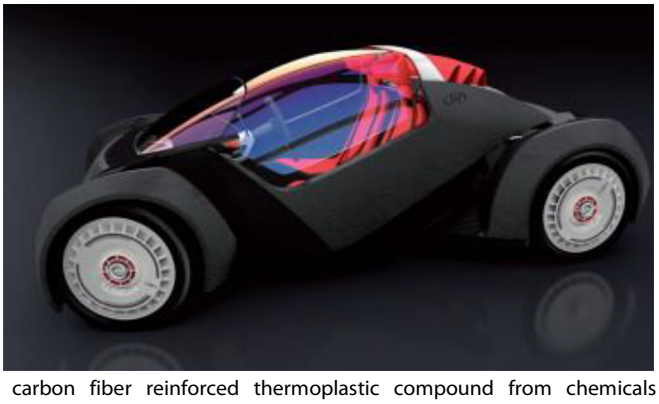
Solvay is developing other specialty fiber-reinforced polymers for AM in Alpharetta, including AvaSpire polyaryletherketone (PAEK), KetaSpire PEEK, and Radel polyphenylsulfone (PPSU) for FFF, and polyetherketoneketone (PEKK) compatible with SLS. This year the company developed three polymer filaments for use in 3D printing based on KetaSpire PEEK and Radel PPSU polymers. KetaSpire is available as a PEEK product and a 10% carbon fiber-reinforced grade. Both PEEK filaments are designed to allow improved fusion of printed layers, enable high part density and deliver improved part strength, Solvay says.

Radel PPSU reportedly offers high transparency, improved elongation and improved toughness for 3D printed parts.

Solvay also plans to develop a powder based on its NovaSpire PEKK polymer, for AM applications in aerospace and healthcare.

Mechanical wear

EOS, a specialist in AM, was founded in 1989 by Dr Hans J Langer and Dr Hans Steinbichler and is a pioneer in the field of direct metal laser sintering (DMLS). It also provides polymer technology and is now distributing in Europe two fiber-reinforced polymers for AM from ALM, a wholly owned subsidiary of the company.



A carbon fiber reinforced thermoplastic compound from chemicals company Sabic was used to produce the world's first 3D-printed vehicle.

The materials include ALM HP 11-30, a carbon fiber reinforced polyamide 11 material with high strength, impact resistance, and an increased elongation at break. The material is suitable for components subject to mechanical wear that require a minimum level of toughness, including automotive industry applications, particularly for motorsport.

The second composite material is ALM PA 640-GSL, a polyamide 12 material filled with lightweight glass microspheres, providing practically the same properties as a normal glass filled polyamide, but with reduced weight (component density: 0.82 g/cm^3). With a microsphere and carbon fiber filling, ALM PA 640-GSL is suitable for applications that require extremely low weight, high strength, and rigidity in one product. It also features increased thermal resistance and improved surface quality. Application fields include the aerospace, shipping, sports, model making, and motorsport sectors.

ALM FR-106, a flame-retardant polyamide 11 suitable for use in the aerospace industry, is also available.

Large format 3D

Sabic, founded in 1976, is a Saudi diversified manufacturing company, active in chemicals and intermediates, industrial polymers, fertilizers, and metals. It was SABIC was the world's fourth-largest chemical producer in 2013.

In 2014, a carbon fiber reinforced thermoplastic compound from chemicals company Sabic was used to produce the world's first 3D-printed vehicle. Sabic delivered the materials and processing expertise needed to create the concept vehicle using 3D printing during the International Manufacturing Technology Show (IMTS) in Chicago, USA. The fully functional vehicle was printed from scratch and assembled by automotive design firm Local Motors, who collaborated with Cincinnati Incorporated, a manufacturing system builder, Oak Ridge National Laboratory (ORNL), a pioneer in advanced materials research, and Sabic to develop and validate the technology and materials needed to deliver large format 3D printing technology.

EOS is now distributing in Europe two fiber-reinforced polymers for AM.

Sabic's LNP STAT-KON carbon fiber-reinforced compound was reportedly used due to its strength-to-weight ratio and high stiffness, which minimizes warping during the 3D printing process.

'Sabic's materials and processing knowledge, together with this advanced AM technology, will help to address the manufacturing challenges our customers are facing – the high cost to innovate,' said Tony Cerruti, marketing director, Americas, at the time. 'We believe that this technology has far-reaching potential for applications across the multiple industries that Sabic serves, bringing designs to market faster and enabling mass customization.'

The concept vehicle event stemmed from a Local Motor's Design Challenge which resulted in the submission of over 200 entries from more than 30 countries. The winning concept, Strati, inspired the full-sized 3D-printed prototype.

End-use parts

In 2017, Sabic introduced its first six new filaments for fused deposition modeling and eight Thermocomp AM compounds for large-format AM. In late 2017, the company announced a filament based on Lexan EXL polycarbonate copolymer technology that is available only from Sabic.

This year, the company has introduced three new plastic filaments for AM. The materials, suitable for fused deposition modeling, are Ultem AM1010F filament for general high-temperature applications, including tooling and Ultem AMHU1010F and Lexan AMHC620F filaments for healthcare applications. They can be used for end-use parts as well as prototypes.

Sabic has introduced three new plastic filaments for AM.

'Our commitment to provide customers with advanced, high-performance compounds and filaments for AM remains strong,' said Keith Cox, senior business manager, AM, Sabic. '[The] launch of these three additional filament products, together with plans to continue expanding our AM product portfolio, demonstrate Sabic's determination to further the evolution of this technology and enable application innovation.'

Ultem AM1010F provides high heat resistance (a glass transition temperature of 217 °C) and high mechanical strength. It can be used in applications such as short-cycle injection molding tools, carbon-fiber layup tools, and automotive components. The filament is UL94 V-0 compliant at 1.5 mm and 5VA compliant at 3.0 mm.

The Ultem AMHU1010F and Lexan AMHC620F filaments are made with Sabic healthcare-grade resins. The same base resin materials are available in injection molding grades for production.

Ultem AMHU1010F filament is a polyetherimide (PEI) product, manufactured from ULTEM HU1010 healthcare-grade resin that provides high heat resistance. The unpigmented filament is biocompatible (ISO 10993 or USP Class VI), and printed parts can be sterilized using gamma radiation, ethylene oxide (EtO) or steam autoclaving. It is UL94 V-0 compliant at 1.5 mm and 5VA compliant at 3.0 mm. LEXAN AMHC620F polycarbonate (PC) filament, available in white, is also biocompatible and can be sterilized with gamma or EtO methods. This filament meets UL94HB rating at 1.5 mm.

Both new filaments are potentially suitable for a variety of medical devices, including conceptual modeling to functional prototyping and end-use parts. Possible customized or personalized applications include surgical instruments, single-use devices and casts/splints.

EOS; www.eos.info
Lehvoss; www.lehvoss.co.uk
Sabic; www.sabic.com
Solvay; www.solvayam.com

ELSEVIER

FEATURE

Bio revolution for UK rail

Liz Nickels

Liz Nickels spoke to a UK composite manufacturer that has developed an environmentally-friendly component for UK rail that also meets the industry's stringent safety demands.

TRB Lightweight Structures Ltd, based in Huntingdon, UK, is one of the country's more established composite component manufacturers, and has a partnership with Seisenbacher, an Austrian rail interiors company and Ellamp a lighting company and we represent each other both in Europe, the UK and in the USA.

Previously known as Technical Resin Bonders Ltd, it has been in business for over 60 years, manufacturing tools and components for a variety of applications ranging from Rail and Formula one to Automotive and Aerospace.

More recently it has been at the forefront of the development of innovative, sustainable materials, with the launch of a new biocomposite resin-based carbon fibre reinforced (CFRP) sandwich panel door leaf with a 100% recycled foam core.

Despite its revolutionary material choice, the door leaf meets all rail fire standards for both overground and underground rail use.

It easily passes BS 6853 and BS 476 and the new EN 45545 to HL3.

External test house data sourced by TRB shows that the sandwich panel system when tested to BS 476 Part 7: 1977 for 'Spread of Flame' achieved a Class 1 Category 1a rating, with a 30% less recorded flame spread of 50 mm in the 1.5 min test time.

Manufacturing of the leaf included the development of a new, proprietary carbon fibre compatible bio resin matrix system that is created from a sustainable and "green" resource.

This system is non-toxic and does not use volatile organic solvents. It is based on a Polyfurfuryl Alcohol (PFA) resin derived from a natural waste bi-product from refined sugar production.

This has resulted in a 'green' composite material option for carriage door leaves which it says is available at a comparable cost to aluminum bonded door leaves, with a 35% weight saving from 40 kg to 26 kg.

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

According to Lyndon Newman, who is a Chief Engineer at TRB, the part is based on similar concepts already used in the Aerospace.

'This system provides very high strength high modulus material at the same time being a greener resin as opposed to the current industry recognised Phenolics'.

Recycled core

The foam core used in the rail door leaf is also produced from 100% recycled consumer plastic from reused drinks bottles.

'We are extremely pleased with the overall performance data, in particular the FST specifications achieved,' said Lyndon. 'In the 30 years I have been in the industry I have never seen such impressive fire performance test results for a non-phenolic based thermoset system.

We initially developed this biocomposite product for rail door leaves, but it could be used for other mass transport interior applications. We have brought aerospace prepreg technology to our rail customers and can now offer them a truly 'green' material design option that is 35% lighter than a bonded aluminum door at a comparable cost.'

I spoke to Lyndon about the company's focus on biocomposites, and what that might mean to its development. He said that end users are becoming more interested in using sustainable or green composite parts. However, some industries are quicker on the uptake than others.

'The problem is that phenolic is a dangerous material to manufacture in its raw state and even when it's processed into a finished component you have to take care, for example if you drill into it and produce dust, there's a potential health issue.

As a result, some companies have started to work on alternatives that are greener to manufacture, more sustainable and don't require a large chemical plants for manufacture.'

 https://doi.org/10.1016/j.repl.2018.10.003

Will the use of recycled plastic in foam cores grow in the future? 'I think it's fair to say that everybody is becoming very aware of the need to recycle plastics in the environment,' he said. 'Younger engineers joining companies right now are very focused on choosing the 'green' option when looking at parts material. It's going to be of interest to people because you're actually doing something that's better for the environment rather than creating more plastics scrap'.

TRB feels positive about the UK composites industry right now, and in particular its diversity.

'The UK leads the way in composite manufacture with products appearing in the marine market with a focus on wet layup and bespoke boat parts, rail components and aerospace components. There are also industries such as specialist carbon fibre tool makers. Then, of course, as everybody knows, the UK is the center of the F1 market.

However, in terms of rail applications, I think the market may fluctuate because it all depends on who is making what at the time,' he explained. 'The amount of brand new trains being made may get smaller – but that's just until the UK's High Speed Two north-south rail network begins implementation, with plans to build new trains in the early 2020s.'

The future and Brexit. . ..

TRB said that it would be possible to make parts with environmentally friendly fibre, such as flax. 'We have make prototypes using flax. The door part we've made needs a certain degree of performance that can only be provided by the use of carbon fibre, but with other parts there's no reason why we couldn't use a chopped fiber, a hessian fabric or flax.'

Finally, I asked Lyndon about what affect Brexit might have on UK composites. 'Brexit is a great big grey area at the moment, so until March 2019 I don't think anyone can predict what is going to happen, however, German and Spanish companies are investing in plants in the UK to manufacture rolling stock, because the UK rail industry market is growing at the moment.'

So, this is a clear indication of future commitment coming out of Europe.

TRB Lightweight Structures Ltd;
www.trbls.com

TRB can now offer the rail industry a sustainable, 'green' biocomposite material option for carriage door leaves at a comparable cost to aluminium bonded door leaves, with a 35% weight saving.

ELSEVIER

FEATURE

Designing effective waste storage systems

Udo Fröhlingsdorf

It is highly probable that most users of temporary storage systems for waste and recyclables will hardly give the container a second glance. The waste industry is after all not the sexiest of sectors and collecting waste is a necessity. Nevertheless, while waste collection has always been a requirement since the earliest days of civilization, today it is undoubtedly a critical activity that is absolutely essential to support our modern lifestyles.

At the same time, we are all becoming far more conscious of the impact that this modern lifestyle is having on the environment. In the case of waste, this means that many of us no longer simply throw all our rubbish into a single bin, but do our best to separate and segregate it as part of the drive to maximize its potential to be recycled.

And whatever the reason for placing the waste into a temporary storage container, we take for granted that the process will be as easy as possible and that the container we are using will be able to cope with whatever we throw into it.

For this reason, the design and manufacture of these temporary storage systems has become a specialized industry, ensuring that the solutions created enable the waste management industry to streamline their processes and operate more efficiently, and in this way, achieve their sustainability goals.

There are a number of critical factors that need to be considered in the design of any new storage container. In particular, it is important to take the entire system and the logistics and application chain into account, including requirements for filling, emptying, handling, and health and safety.

There are very diverse systems in the market – from bins in city centers to underground systems with large filling volumes. Even though many of the criteria for developing a container are the same, the approaches and solutions have to be different ones. Let's focus on two and four-wheel plastic containers for now.

Safety and functionality are of course key – both for the depositors of the waste and for those who have to collect it. This concerns product quality as well as compatibility with different emptying systems all over the world. Imagine a fully loaded four-wheel bin in the lifting device of an emptying truck – it may weigh more than 500 kg and still needs to be held safely in place during the whole emptying process. For this reason, the interface between container and lifting device is a determining factor as well as compliance with national and international norms and the respective standards and quality marks.

However, within these boundaries there is still a lot of room for the creativity to design innovative solutions. Aside from quality and safety the main requirements for these types of containers today are functionality, ergonomics, user-friendliness, eco-friendliness and sustainability, cost-efficiency and longevity (Figure 1).

One of our most significant recent developments, the split lid container, illustrates a typical product development process within ESE. 1100-liter containers are widely used and their number is continually increasing. There have been two types: bins with sliding or round lids and bins with flat lids. Both have their advantages and drawbacks. Standard large lids and other solutions such as lid-in-lid versions are prone to collisions with press plates of the collection trucks or waste already in the truck during the emptying process. Such problems do not usually arise with round-lid bins, but these are costlier and more maintenance-intensive. In addition, the trucks need to be equipped with a special lid-opener in the lifting device. Round lid bins need to be equipped with a child safety device and both solutions are far from perfect in handling, ergonomics and user-friendliness due to their height, and the size and weight of the lids.

The challenge was to find a solution which maintained the benefits of the 1100-liter container and at the same time develop a flat lid design which can be emptied without problems by each

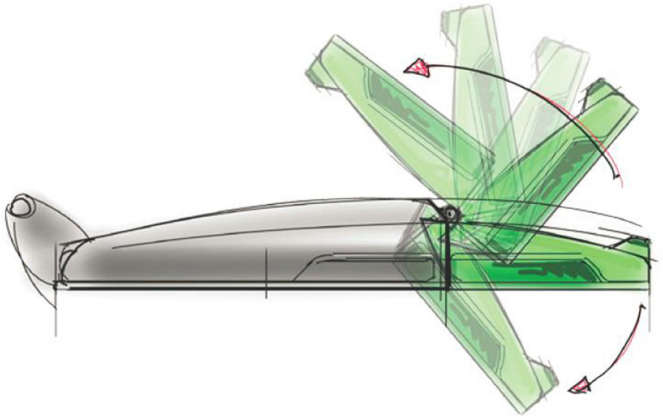


FIGURE 1

Split lid container.

collection vehicle while still possessing the ergonomic advantages of a round lid with small lid-in-lid system. Apart from these technical requirements we also seized the opportunity to develop a stylish product with additional features that would set new standards in the market.

Ergonomics has been key to the design of the SPLIT LID with only the front third of the lid opening. This makes it much lighter than a complete lid, requiring around 60% less effort to open. Equally important, a central open handgrip in the middle combined with an additional lip handle all around the edge means it can be opened very easily by children, the elderly and people with a disability. The lateral handle also makes the lid easy for wheelchair users to operate. The lid stays open in a position that makes closing similarly effortless, and it is child-safe (Figure 2).

In addition, the design enhances the overall deposit procedure. As the lid can be completely opened without difficulty, the bin can be filled with one hand, an especially useful feature when there are several waste bags to be disposed off. The fact that it is not essential to open the whole lid is a particular benefit when the bin is placed close to a wall. And because it is now easier to fill the bin, problems of bin lids being left open are significantly fewer.

To avoid the previously-mentioned problems in the collection and emptying process, the SPLIT LID container has also been designed to provide several new user benefits. Compared with standard flat and round lids, the split lid design allows the front lid to hinge in either direction, meaning the lid simply gives way to avoid the possibility of damage (Figure 3).

Sustainability is another important goal for us as well as for our customers, many of whom are in the recycling business themselves. Since one of the key roles of the containers is to help facilitate the collection of material for recycling, it makes sense that the container itself is designed with sustainability very much at the forefront.

Product design is at the beginning of a sustainable product. A container needs to be thought-out right from the start to meet the requirements for stacking and transport optimization, optimized use of materials and low energy consumption during production, low noise emission and 100% recyclability.

FIGURE 2

Problems of bin lids being left open are significantly fewer.

FIGURE 3

The lid simply gives way to avoid the possibility of damage.

HDPE, the main material in the manufacture of these containers, has a very high impact on the eco-friendliness of the product. Apart from saving 100% of raw oil, the production of recycled HDPE only uses about 13% of the energy necessary for the production of virgin material. The total environmental

impact of the production of recycled HDPE adds up to only about 22% of CO2 equivalents of the production of virgin HDPE.

Our plastics bins have also been the first worldwide to be awarded the globally-recognized Blue Angel ecolabel which has very strict standards. Containers must be made from at least 80% post-consumer recycled plastics, and material, production site and processes all have to be certified by an independent accredited institution to confirm the sustainability claims.

However, using recycled HDPE in the production of bins is a challenge. AT ESE this has been achieved thanks to our more than 25 years of experience and expertise in the use of recycled materials, along with continuous research and development by our specialists that helps to ensure we are always ahead of any changes in the market.

With so many factors to take into account, it is hardly surprising there have been a great number of enhancements and advances in the design of waste storage systems over the years, in particular as manufacturers have responded to changing market requirements.

For example, we have introduced larger volume containers, with two, three and four-wheel variants in order to match the size of the container with ease of maneuverability. For effective separation of material within one container, two and four compartment bins have been developed. Some four compartment systems also now contain further smaller specialized bins for additional separation of materials. All these bin systems are also prepared for integration in IT waste management systems for data management and accounting.

Waste storage systems have come a long way, developing and adapting to meet the challenges of today's modern world. Waste collection will undoubtedly continue to set new challenges in the future; managing these effectively will depend on the continual introduction of intelligent solutions that are fit-for-purpose while meeting the needs of sustainability, recycling and the protection of ever scarcer resources.

ELSEVIER

Roctool LIT: A high performance and cost-effective solution for automotive and aeronautical applications

FEATURE

Lionel Schaal

While cycle time remains a high target for the composites industry whose annual production volumes are exponentially growing, final part's cost is critical to most applications. To comply with those requirements, the material supply chain has been developing a wide range of products including fast-curing thermoset composites and lower cost thermoplastic based materials; in parallel, more and more manufacturing processes are being developed, which are getting more efficient but usually vary in part's quality.

For the automotive industry, integrating a composites production line represents a large capital investment, with the risk of purchasing a custom solution which may not be appropriate for future applications or adapted to evolving materials. This is true for large or 3D products, where amortizing the acquisition of a very large press can only be justified by having a few major programs confirmed.

In the aeronautical industry, bottle necks are often linked to hand lay-ups and the use of autoclaves, which present high running costs and require regular and extensive maintenance. Alternative solutions such as stamping processes are already in place for small components, but with a clear limit in part's quality, dimensions and geometries. For large or 3D products, finding a viable OOA (Out-Of-Autoclave) solution which enables the highest part's performances is a challenge.

For this range of applications, Roctool developed the LIT™ (Light Induction Tooling) technology. The manufacturing cell offers a more efficient and more economical way to process a very wide range of composite materials, achieving short cycle times and exceptional part's quality. This turn-key solution is dedicated to large parts, and has been proven to work very efficiently on 3D products or complex geometries (Figure 1).

Efficient process integration

The Roctool LIT™ is now commercially available as a stand-alone solution to manufacture composites parts. It offers a full and accurate control over the parameters among which temperatures and pressures – including vacuum through the composite material. Its automation is delivered by a specific control unit, with the ability to connect to previous and next process cells.

Turn-key and autonomous solution

LIT™ stands for Light Induction Tooling and corresponds to the mold design and the integration of Roctool induction technology within. This solution can be used in a conventional press or autoclave, for instance to increase the thermal performance of heated platens or to heat both faces of the composite; this allows a better thermal control throughout the part, optimizing mechanical performances and reducing void content or internal stresses.

Roctool performed a study for an aeronautical program, aiming at comparing the heat ramps within the composite laminate of a sandwich panel. The autoclave ramp is shown on the left; because of the large thermal mass of the tool the A-face remains at a lower temperature and differential heat ramps are observed with a 290 °F gradient through the material. Using Roctool and aiming at a 15 °F/min heat ramp, this gradient is reduced below 40 °F over the same period (Figure 2).

The LIT™ has then been extended to be proposed as an OOA solution where temperature and pressure controls are critical. Its last evolution is available as a turn-key manufacturing solution, where the technology is embedded in a simple but robust autonomous structure facilitating the investment over a large press. Its automation has also been developed to be integrated in a production line, with a full automatic mode and Industry 4.0 standards.

Induction mold technology

Roctool's patented technology consists in placing technical elements referred to as "inductors" into a metallic tool, in order to provide heat. The flexibility of those inductors allows them

 https://doi.org/10.1016/j.repl.2017.10.002

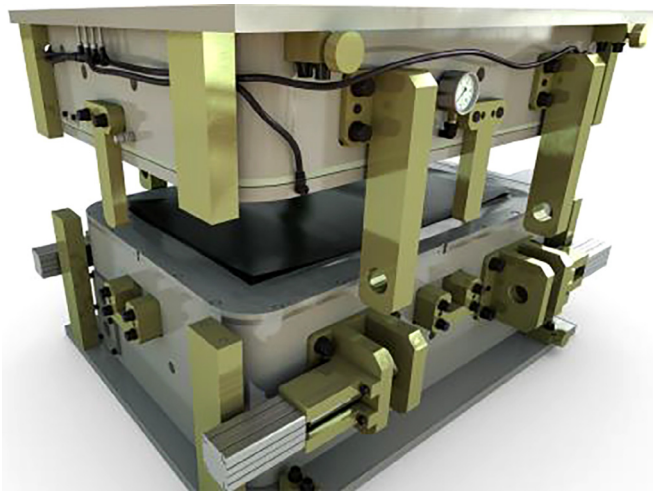


FIGURE 1

LIT™ (Light Induction Tooling) technology.

to follow complex 3D shapes, and a large range of integrations are available to match at best customer's requirements. The LIT™ uses the same technology under new patents, integrated in a thin shell tool; this enables a refined temperature uniformity, a better dimensional stability and the ability to heat faster while reducing energy consumptions.

Tool-building can be performed following different methods including additive manufacturing; the selection will highly depend on the geometry complexity of the final part. The induction technology will then be optimized within the LIT™ shell by Roctool engineering team in order to obtain the highest part's quality, following customer's requirements (Figure 3).

As tooling investments can be high for large parts or when considering a number of references, the Roctool integration has been standardized and capital savings up to 40% can be achieved compared to more standard processes.

Interchangeable mold system

With fast Heat&Cool cycles, the LIT™ is optimized for productions with difficult requirements involving temperature and pressure controls or larger than 50 k parts/year. If smaller volumes are considered on a large number of references, the tool can be equipped with Roctool latest quick connections, allowing for an efficient change of the tool in a single supporting structure (Figure 4).

The system, available for production lines early in 2018, will enable manual or automated connection to the mold; the different mold references could be stored away from to the molding machine, with QR codes available on each of them to speed up the process launch on a new production while avoiding operator's errors. Similarly, further automation before and after the molding process can simply be adapted around the LIT™ process solution.

Optimized for composites

The Roctool LIT™ is available in different configurations, and able to transform the full range of composite materials. For

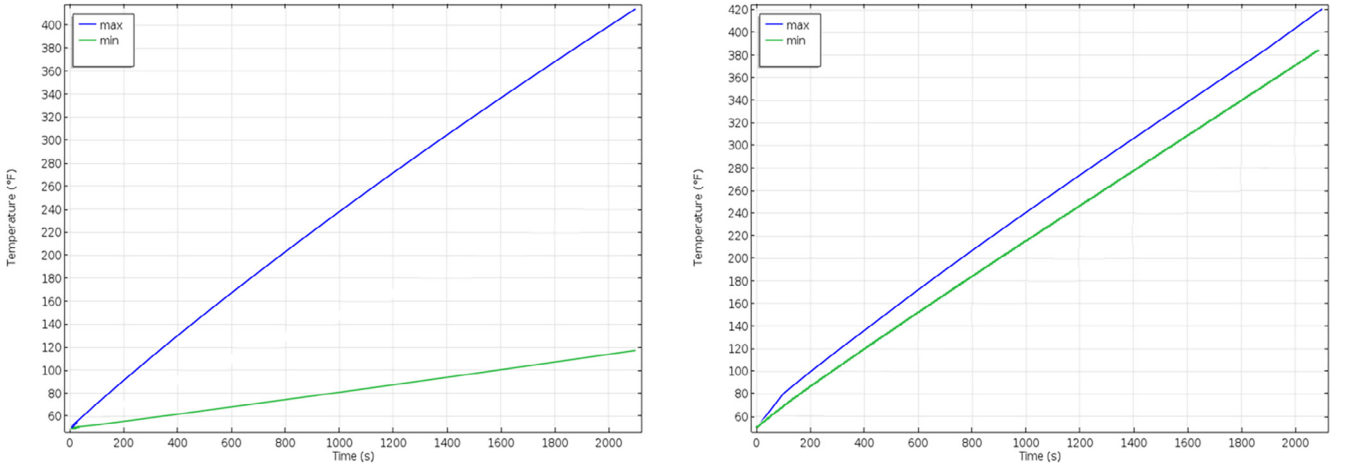


FIGURE 2

Thermal gradient through a sandwich laminate, consolidation in an autoclave and using Roctool LIT™ technology.

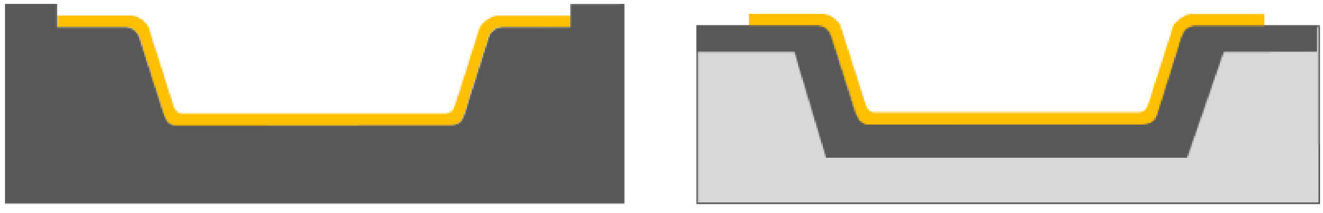


FIGURE 3

Regular large tool for compression molding, vs. the LIT™ shell tool on its supporting structure.

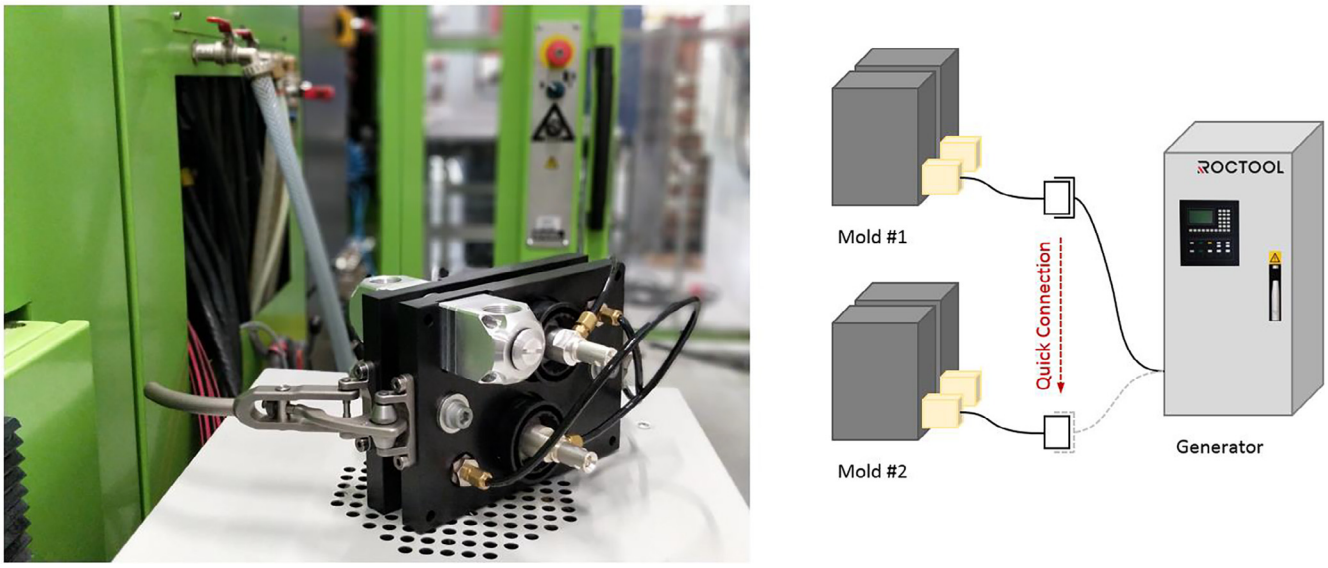


FIGURE 4

Roctool quick connection, linking the Roctool generator system to interchangeable molds.

thermoplastics large heat rates are possible to shorten cycle times, as well as high temperatures dedicated to performance materials. With thermosets the focus is generally more oriented toward preset heat ramps and thermal control during the process.

Fast and accurate heating

For composite productions using thermoplastic-based materials, reducing the heating step is critical since the material will only start its consolidation once reaching high enough temperatures. Being able to heat the mold rapidly, at rates up to 150 °C/min, not only enables a cycle time reduction but a better consolidation of the composites at higher temperatures can be obtained. Part's performances and quality therefore improve drastically.

For challenging materials, temperature uniformity over the molding surface is crucial. The Roctool engineering team performs FEA on all incoming applications in order to optimize to customer's requirements; at the highest rates it is possible to obtain below 5 °C temperature variation on the molding surface, while during the holding stage this value can go down below 2 °C. Both the cycle time and the nature of the mold material used for the mold will influence those values.

High temperature capability

More and more applications require high mechanical performances, high glass transition temperatures or fire resistant properties. The composite materials used are based on highly engineered thermoplastics, which require high heat capability for their consolidation. The Roctool LIT™ can achieve 400 °C in different standard configurations, enabling the transformation of any thermoplastic-based composites.

A temperature profile is given as an example below, on a process reaching high temperatures for the aeronautical industry. This configuration is defined as having 2 sides heating, for which the temperature uniformity is kept well. For the product considered no dwell time is necessary, which is not common for most materials considering their thermal properties and presentations (Figure 5).

To obtain optimal performances of the final product, when using high temperature semi-crystalline matrix systems such as PEEK, PEKK and PPS, it can be of interest to better control the cooling speed in order to reach higher degrees of crystallinity. The table below shows results for a few constant cooling ramps, as well as maintaining during 5 min the mold at different temperatures when reaching target temperatures (Figure 6).

In order to optimize the cycle time for such materials, a non-conventional cooling stage can be proposed with improved results. A fast rate can be used down to a target temperature, at which the mold would be kept isothermal during a selected duration or set at a slower cooling rate, before ending the cycle at an even faster rate – thus ensuring high performance and short cycle times.

Controlled and staged ramps

A large number of industries are still using thermoset-based materials, in particular in the aeronautical and automotive fields where the use of carbon fiber/epoxy resins prepregs remain dominant. Generally a highly accurate heat ramp is set by the material supplier, and different holding stages are recommended to allow for flow and then reticulation through the composite.

The Roctool LIT™ has been tested with a range of fast curing prepregs, for which Design Of Experiments were conducted in order to better assess the mechanical performances to cycle time ratio. In this configuration vacuum could be drawn out through the tool, while a reusable membrane or conventional consumables were used on the B-face (Figure 7).

Results were not only showing an excellent consolidation of the composite leading to the highest performances of the part, but also exceptional surface quality. The aim of the study was to compare current technologies with the Roctool LIT™ and

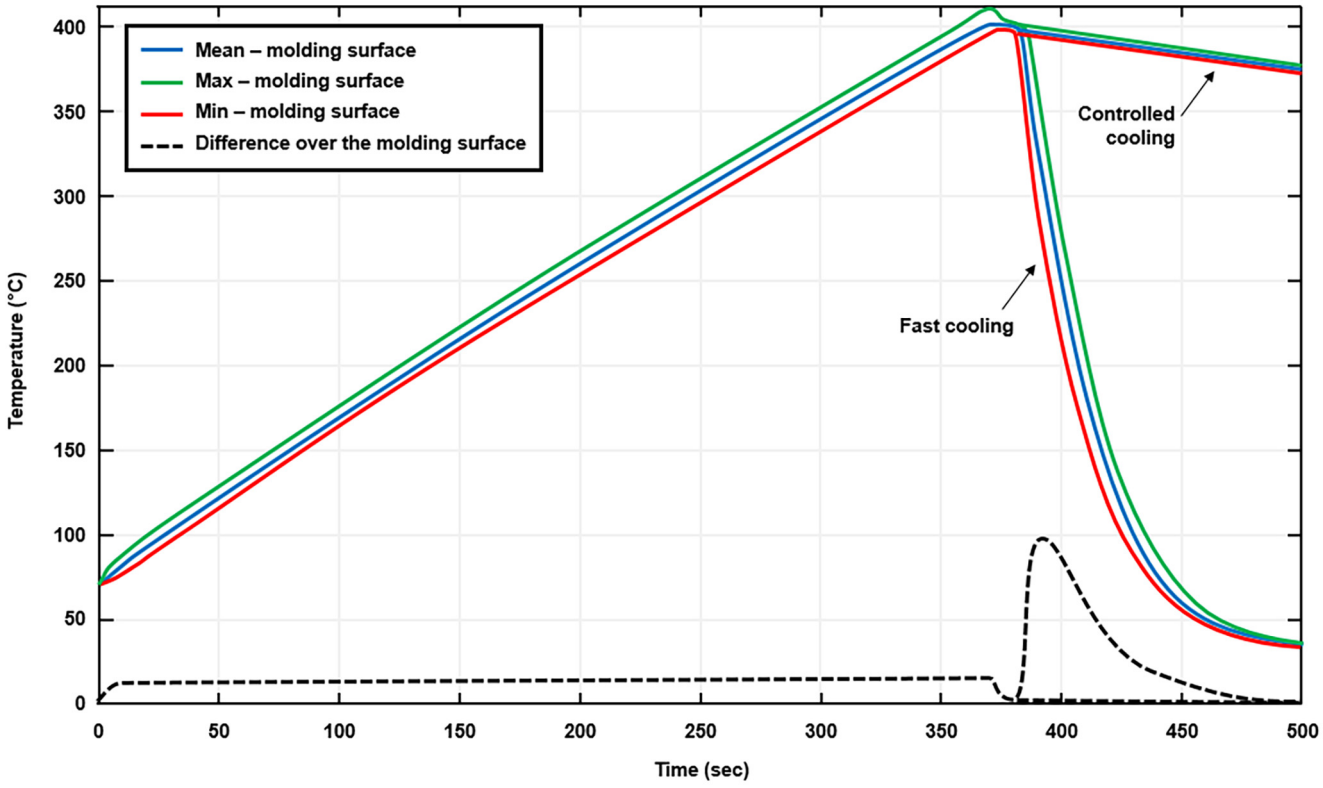


FIGURE 5

Temperature profiles on the molding surface of an aeronautical application, using the Roctool LIT™.

Cooling rate	1°C/min	10°C/min	20°C/min	20°C/min	20°C/min	20°C/min
Holding step	-	-	-	300°C	310°C	315°C
Degree of crystallinity	46.5	41.3	31.5	35.6	35.9	33.2

FIGURE 6

Degree of crystallinity for a PEKK composite, following different cooling ramp and hold strategies.

assess the potential savings in painting; deflectometry and gloss unit measurements were performed, for which some of the results are highlighted above (Figure 8).

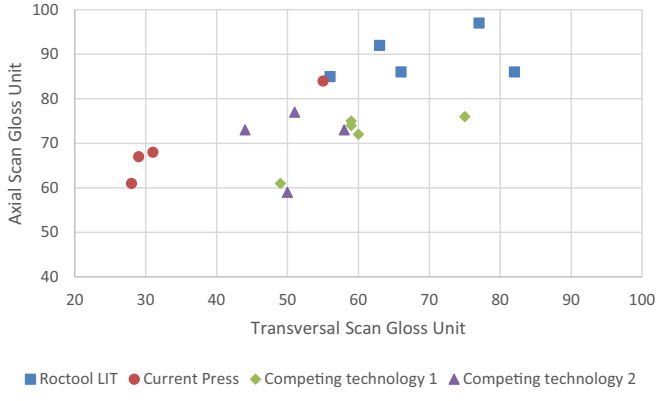


FIGURE 7

Axial and Transversal Gloss Unit measurements, for different technologies including the Roctool LIT™.

Dedicated for large parts

The Roctool LIT™ can be adapted to smaller parts with very difficult process parameter requirements, but it is truly optimized for larger parts. When reaching intermediate dimensions, the process can outreach most performance requirements while being economically viable; for very large laminates it places itself as the only manufacturing solution for composites.

Mold design requirements

A large range of tooling material grades can be considered for a LIT™ solution, with temperature and investment limitations which are generally linked to the application as specified below:

- Nickel alloys: standard nickel is usually available at low hardness levels, while nickel/cobalt alloys reach levels which achieve higher stability under higher pressure levels. Temperatures respectively can reach up to 220 °C or 250 °C, therefore adapted to automotive thermosets, TPO skins and some PP- or PET-based composites. This material can be built using electro-forming – an additive manufacturing process.

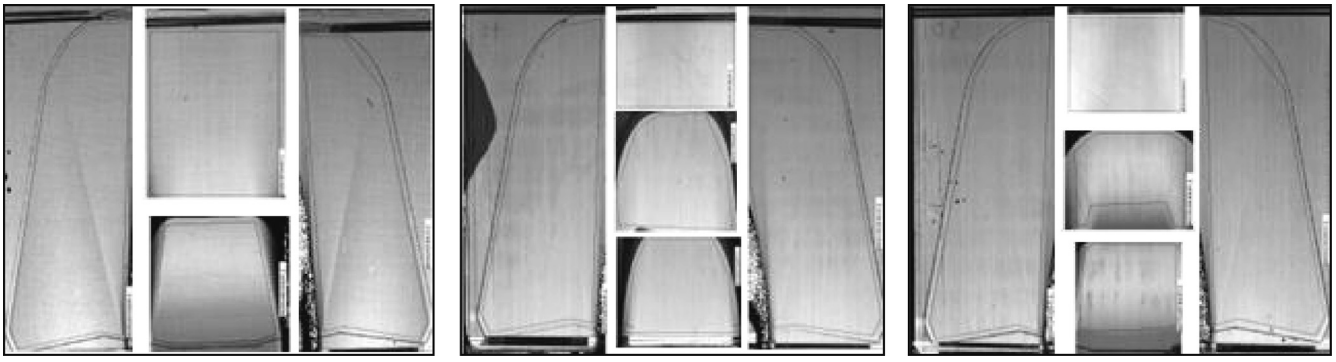


FIGURE 8

A/C scans of the 3D product transformed using the Roctool LIT™, showing minimal void content.

- Steel alloys: a very wide range is available and compatible with the Roctool technology, from regular to high hardness, and from high conductivity (such as the HTCS130 supplied by Rovalma) to more standard materials (such as 1.2311 and 1.2343 grades). Temperatures up to 400 °C can be achieved, leading the way to the manufacturing of any TP-based composites, through a controlled investment cost and standard tool-building equipment.
- Invar alloys: a wide range is available, which is particularly well suited for large aeronautical parts thanks to its low Coefficient of Thermal Expansion, which facilitates dimensional stability. Each grade would have a Curie temperature, above which the metal becomes nonmagnetic – thus enabling an excellent thermo-regulation around this well-defined temperature. Invar alloys are commonly more expensive than conventional steels.

Low energy consumption

The tool design and construction is focusing on reducing to a minimum its thickness and therefore thermal mass. This has a direct effect on the heat ramp and temperature uniformity capabilities, but also enables a mass heating of the tool; heating the tool totally through its thickness allows for a greater mold stability. Indeed, if a temperature gradient through the tool thickness was to appear, a deformation in the *z*-direction would be affecting the part's quality, while reducing the tool lifetime.

On a low thermal mass tool, the energy consumption used to heat at a set temperature is obviously kept to a minimum. With the LIT™ configuration, which is connected to a highly energy efficient Roctool generator, the global energy consumption has been computed on an 800 × 450 mm panel, for different TP-based composites. This study shows that the LIT™ technology not only enables an investment cost control, but also drives a large reduction of those running costs (Figure 9).

Heating distinct zones

Some heating strategies may require to heat different zones of the tool independently. This can be performed through the use of a Dual-Zone generator system, which for each zone will be feeding an induction circuit and be connected to a thermocouple for control.

For a larger number of zones, different generator systems can be used, all controlled by a central software enabling the use up to 12 systems at once.

This capability can either be used for highly 3D tools aiming at an excellent temperature uniformity over the molding surface, or for tools used to consolidate thermoset laminates with various thicknesses. In the latter case, the heating strategy could be focusing on pre-heating the thicker section of the laminate, or on adding more thermal energy in this thicker section, in order to obtain a homogeneous temperature through the composite laminate. As an OOA solution, this option can lead to a more accurate control over the curing process, and shorter cycle times (Figure 10).

Adapted to 3D geometries

Each industry has parts which present highly 3D geometries, or to minimize the assembly of smaller parts will consider manufacturing a larger and often geometrically more complex part. When considering box shapes, sharp angles, local recess, deep draws, the high temperature and pressure gradients on conventional processes often lead to poor product's quality.

	TPO	Epoxy	PP	PA6	PA66	PPS	PEKK
Process temperature	120°C	190°C	225°C	260°C	290°C	315°C	380°C
Process cycle time	<1 min	3.5 min	2.0 min	2.5 min	3.0 min	3.5 min	5.5 min
Energy consumption	<0.10€	0.14€	0.15€	0.19€	0.22€	0.24€	0.29€

FIGURE 9

Process temperatures, cycle times and energy consumptions for a medium size panel – using the LIT™.

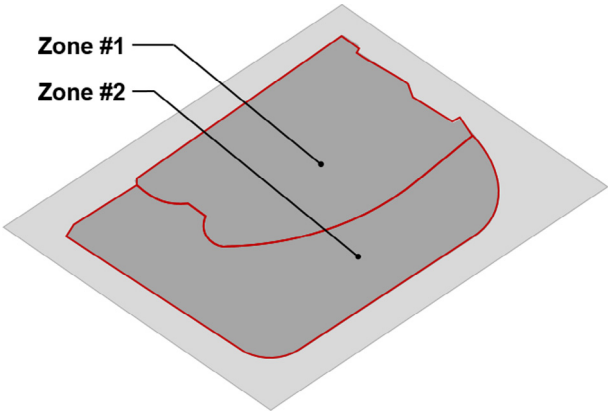


FIGURE 10
Tool with 2 distinct & independent heat zones.

Optimization through FEA

A Roctool project always starts with an extensive analysis using a specific Finite Element Analysis software; this necessary step will drive qualified engineers to select an optimized integration of the Heat&Cool network in a LIT™ tool configuration. Through this analysis all the parameters linked to the induction and water channels are studied and analyzed, in parallel with the tool's thickness, construction and edges details (Figure 11).

Flow analysis on a complex part, and thermal analysis on a LIT™ tool – both for automotive applications.

On a complex part's geometry, the cooling channels may require a specific flow analysis in order to assess the cooling homogeneity along their path. On another hand, the Roctool induction hardware is fitted to the model to obtain a representation of the thermal activity on the molding surface during the compression cycle. The thermal analysis can also be completed with a thermo-mechanical study in order to assess potential deformation and fatigue. All these data are further confirmed by direct measurements during the installation of the tool on-site.

Conformal Heating & Cooling

An ideal configuration to obtain highest thermal performances is to use a conformal Heat&Cool network. In such a configuration, the induction and water cooled channels follow the geometry of the part, and the tool thickness is kept relatively constant. Different tool-building technologies are available to obtain a LIT™ tool with such characteristics:

- Brazing on a shell: this sequence consists in building a tool with a series of grooves in its back, before brazing formed plates above the cooling channels to have them watertight.
- Formed 2D shell: in this case the heating and cooling channels are respectively grooved and drilled from a flat sheet of metal. The 2D shell is then formed using specific equipment in order to give it its final 3D geometry.
- Additive manufacturing: only adapted to certain metals, this approach remains an ideal option for its versatility and ability to build very complex geometries. The optimization of the profile through FEA enables the finest performances in terms of temperature uniformity, thanks to the addition of complex profiles on the edges to limit their effects (Figure 12).

The results obtained while using a conformal Heat&Cool tool are double: highest mechanical performances of the laminate, and excellent surface quality with a homogeneous gloss over the surface. When using the LIT™ technology, the limit in geometry tends to not be linked to the tool requirements, but to the type of composite material to be molded.

Isotropic pressure distribution

Most compression processes tend to promote the use of a press in order to apply the required pressure. For complex geometries a high tonnage press is often recommended, which applies a very large downward force in order to retrieve sufficient sideways forces to consolidate the vertical sides. The material therefore has variable properties through the part since its consolidation had different pressure levels, while the horizontal areas are usually distorted due to high pressures.

In order to avoid this phenomenon, the LIT™ can be integrated with a flexible and reusable membrane, which will distribute the pressure over the part's surface. In this configuration pressures up to 25 bars are industrially possible, while the membrane can form up to a few thousand parts before needing a replacement. It is particularly well adapted to lower temperature matrix, and to applications where tooling cost is a critical part of the investment (Figure 13).

The effect on the material is mostly seen on the mechanical performances and their stability over the product's surface. For low viscosity matrix such as thermoset resins, it is recommended

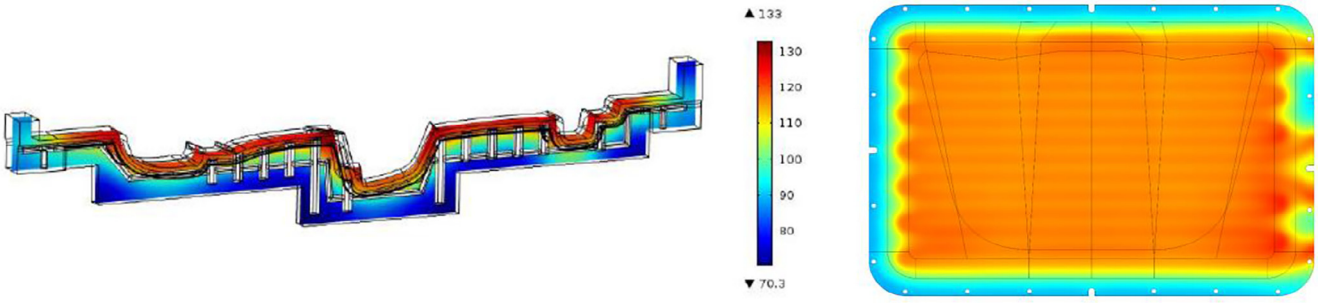


FIGURE 11
Finite Element Analysis.

FIGURE 12

Details of 3D complex geometries for which a conformal Heat&Cool cycle is required.

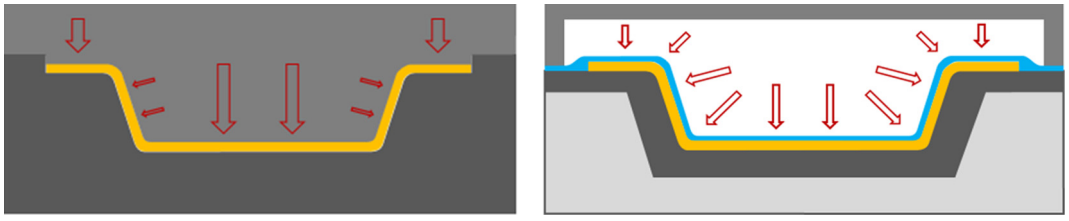


FIGURE 13

Pressure distribution through the material in a conventional process vs. in the LIT™ with a membrane.

to also complete the integration with a vacuum capability – performed by adding vents in the tool and adapting the membrane technology – to obtain the lowest levels of void content leading to highest product's performances.

Conclusions

Through accurate control over the process parameters, the LIT™ stands as a high-performance manufacturing solution. It enables the transformation of a wide range of composite materials, leading to parts with high mechanical performances and perfect surface quality. Its specific mold integration, which holds some of Roctool's latest patents, is versatile enough to adapt to most large and complex geometries; its engineered mold design facilitates the customization of the process to match automotive and aeronautical requirements.

Proposed as a turn-key solution, the LIT™ can be seamlessly integrated into current or future production lines. Its controls are fully compatible with potential specific automation around the process, and its software can export quality control data in order to optimize the production rate or the product's performances through designed iterations. Globally, the LIT™ solution also contributes to managing costs around the process, through low energy consumptions even for high temperature composites, and with a controlled capital investment compared to the acquisition of a large autoclave or of a large press.

Often a high performing transformation process is not sufficient, the LIT™ can therefore be coupled in particular with material lay-up equipment. For very large structural parts, an ATL (Automated Tape Laying) or an AFP (Automated Fiber Placement) can drape directly on the Heat&Cool tool, facilitating the first ply's adherence and enabling a thermal control in order to eliminate potential part's warping. Consolidation or co-consolidation of the component(s) can then be performed directly in the LIT™ tool.

For more complex and 3D parts with mechanical and esthetic requirements, the use of a dedicated preform is always seen as a preferred option. Different options are currently being tested in the industry, offering shorter lay-up times and therefore cost savings, as well as the ability to keep fiber continuity in 3D features such as corners and ribs. Those alternatives are proposed under various patents: knitting structural yarns, stitching a continuous yarn on a backing textile or film, welding tape plies, or more simply counting on the high deformability of non-woven materials.

Overall the material supply chain and the selected process are strongly linked in order to deliver products matching OEM performances, quality and cost expectations. This technical complexity naturally leans toward customized installations, which may tend to lose their versatility for other products or programs. The decision process is therefore forced into the acquisition of standard equipment with lower performances; but with the industry global growth, manufacturing solutions combining product's quality and efficient processes are starting to become a necessity.

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FEATURE

Composite technology for high volume lightweight manufacturing

Dave H. Bank *, Allan James, Selamawit Belli, Jason R. Reese, Richard E. Baumer, Bharati Balijepalli, Liangkai Ma, Martin Reimers, Rainer Königer, Timothy Morley, Luca Lotti

Dow Automotive Systems

This article describes two composite solutions – prepregs and resin transfer molding (RTM). Prepregs describes a new compression molding process that enables mass productions, short cycle times and reduced waste.

This article describes two composite solutions – prepregs and resin transfer molding (RTM). Prepregs describes a new compression molding process that enables mass productions, short cycle times and reduced waste.

The pressure for increased fuel economy and low CO2 emissions for automotive vehicles continues. While automotive manufacturers have made gains in fuel efficiency and reduced vehicle greenhouse gas emissions, meeting the 2025 regulations for fleet average fuel economies requires a step change in vehicle technology.

This is creating a strong business case for mass reduction through use of lightweight structural materials, such as carbon fiber reinforced epoxy composites. Vehicle lightweighting is a particularly important approach due to the mass decompounding that may occur as reduced primary vehicle weight enables secondary mass reductions. The challenge with implementing carbon fiber composites is to make them cost effective for high volume production. Thus, the material must be modified so it can be robotically handled to avoid costly inefficiencies while utilizing existing processing equipment.

Novel prepreg solution for compression molding

The prepreg system developed by Ford Motor Company, Dow, DowAksa and CSP is based on VORAFUSE™ P6300 epoxy intermediates, a formulation developed by Dow and infused into continuous carbon fibers in the format of a fabric. This type of composite material is capable of providing high stiffness and strength, which is required with structural parts such as a B-pillar (See Figures 1–3).

Fabric design

In addition to the quality of the resin, fabric design is key for prepregs. Woven, braided, and non-crimp fabrics (NCF) are commonly used for composites. Of these, woven and braided fabrics are known to be better for preforming than NCFs. A comprehensive formability study was performed for selective fabric types using the bias-extension test method as well as utilizing single-dome and double-dome preforming tools. To meet the static and dynamic loading requirements for B-pillar applications, a triaxial fabric format (NCF or braid) was desired to simplify the ply stack assembly.

Based on its superior formability and mechanical performance, a [0°/60°/−60°] triaxial braid was ultimately selected and tailored to the B-pillar longitudinal stiffness and strength design requirements. The triaxial braid offers superior formability as well as excellent mechanical performance.

Prototype part manufacturing

The [0°/60°/−60°] triaxial braid was pre-impregnated with the epoxy resin from Dow and then converted into a molded composite by creating a laminate stack, consisting of multiple layers of prepreg. For baseline property assessment, three layers of the prepreg were stacked and molded to yield the required mechanical performance.

* Corresponding author.

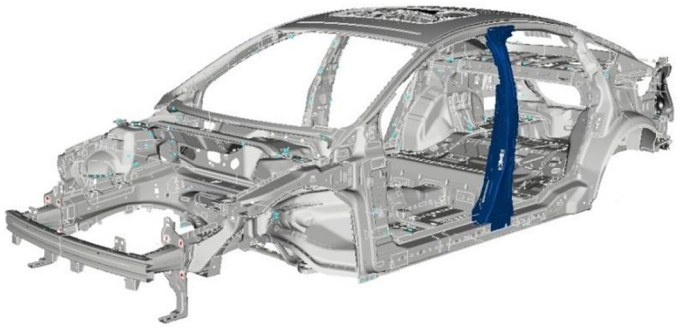

FIGURE 1

Ford Fusion body in white with B-pillar highlighted. This is an example of prepreg application developed by a team of experts from Ford Motor Company, the Dow Chemical Company (Dow), DowAksa and Continental Structural Plastics (CSP).

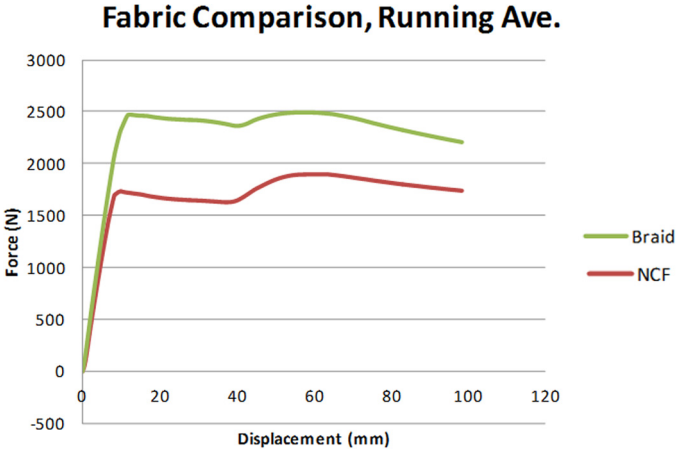

FIGURE 2

Comparison of three-point bending test results of NCF and braided composites.

FIGURE 3

B-pillar preform (left) and molded B-pillar (right).

To achieve the three-dimensional (3D) cured composite part from two-dimensional (2D) braided carbon fiber prepreg, the following steps are required:

- Cutting the required prepreg layers via automated XY cutting table or die cutting.
- Ply stack joining of multiple prepreg layers using heat and pressure.
- Shaping (i.e. "preforming") of the prepreg layers into the 3D geometry of a part before molding and integrated trimming of excess prepreg.
- Preforming as isothermal compression molding forming braided architecture in less than 60 s.

Compression molding

This prepreg solution was designed to work in out-of-autoclave processes like compression molding, to achieve fast cycle times for automotive applications. While this intermediate was developed as a tack-free product, additional intermediates with a range of surface tack have also been developed, to match automated handling opportunities or more typical low volume laminate layup methods. All the intermediates exhibit significant room temperature shelf life allowing for equipment flexibility on the production floor and the avoidance of onsite freezer storage. With fast cure times of three minutes, this novel carbon fiber prepreg enables high volume manufacturing.

The typical process starts by placing an intermediate preform into the compression molding tool. The intermediate preform starts at room temperature, and the tool is maintained at an isothermal temperature ranging from 120 °C to 160 °C. Appropriate clamp pressure based on overall part size is applied to close the mold and compress prepreg layers into a uniform shape. Cure time of the molding process is adjusted based on tool temperature and desired degree of cure before mold opening.

B-Pillar application performance

To validate performance of the carbon fiber design concept, both body side sub-assemblies and experimental vehicles were built to incorporate the carbon fiber reinforcement. Corporate standard testing was performed on the body side sub-assemblies and sub-systems were built and tested for static performance attributes. Experimental vehicles produced with an integrated carbon fiber B-pillar reinforcement, were subjected to 50 km/h side impact testing. Test results and subsequent tear down of the B-pillar structure showed that the vehicle level performance met or exceeded all requirements.

The development has yielded an epoxy-based prepreg designed for high volume manufacturing. The system enables room temperature shelf stable technology that is conducive to automated manufacturing of composite parts. The performance of these materials was validated in production processing scenarios culminating in full vehicle testing.

Finally, this novel carbon fiber epoxy prepreg, with support of a Tier 1 partner, was implemented on the front roof header and nose bottom panel of the 2017 Ford GT as a technology demonstrator.

RTM and wet compression composites for mass production

In addition to VORAFUSE, Dow has introduced VORAFORCE™ epoxy resin systems, an RTM and wet compression solution enabling a 60 s cycle time and a high potential for part and functional integration (See Figures 4 and 5). VORAFORCE was the first carbon fiber composite solution to offer true full mass production capabilities and is in use within VW-group and Daimler for body applications.

The resin technology combined with the manufacturing process is the determining element for production speed, part performance, part complexity, and therefore cost efficiency. The RTM process and derived processes such as wet compression, facilitate high-fiber volume contents. Preforms can be prepared to orient the fibers along the major load paths. It also allows the molding from small and simple shapes up to very complex shapes. Such complex shapes can integrate multiple parts or components which, in typical metal design, would require several assembly and joining steps. For example, instead of producing 28 metal parts and assembling them, one integrated part could be molded.

The standard RTM process is performed in a completely closed mold. The extremely high compression within the mold creates unique challenges for resin injection and cure. The following characteristics of VORAFORCE contribute to the success of using the RTM system.

FIGURE 4

Rear structure with VORAFORCE 5300 (developed for Aston Martin).

FIGURE 5

BMW i3 side frame – a typical CFRP structural RTM application for VORAFORCE.

Viscosity

The injected material should have as low a viscosity as possible. While it is known in the industry, a viscosity of less than 200 mPas is desired to accomplish good fiber wetting and Dow's epoxy system provides a starting viscosity as low as 15 mPas. This reduces the flow resistance through the preform, minimizes fiber movement and allows faster injection. This permits longer flow paths in the same time period and enables production of larger parts. Pressures can be reduced and press forces minimized, reducing required hardware investments.

Latency and cure

Epoxy systems are reactive systems. They are composed of at least two reactive components, an epoxy resin and a hardener. The reaction starts when the components meet. The continuously increasing viscosity limits the capability to fill a mold and can affect feasible molding size and part complexity. The developed system behaves latent, meaning the reaction is delayed, maintains its low viscosity for a long time and increases the window for injection. This allows maximizing flow length and possible part size. On the other side, after the mold has been filled and the preform is wetted out, the reaction should complete as quickly as possible to keep the total cycle time as short as possible. The developed solution enables an injection time of 60 s and a demold time of an additional 90 s.

Wet compression

The wet compression process is an advancement of the RTM process in speed and tailored for 2D-like structures. In this process, resin is applied to the preform outside of the mold. After resin application, the pre-impregnated preform will be transferred into the hot mold which then will be closed. During the closing, the resin will be further distributed within the preform by compression, ensuring proper wetting of all carbon fibers. The part will cure more rapidly at elevated mold temperatures.

After demold of the part, the next pre-impregnated preform is immediately inserted into the hot mold. The decoupling of resin application and the cure in the mold allows further shortening of cycle time. In-mold cure times as short as 30 s have been accomplished with full cure. If the adjacent processes of preforming, resin application, transfer into the mold, and transfer out of the mold are adapted, a complete cycle time of one minute is in reach, enabling production numbers of up to 300,000 parts a year out of one mold.

VORAFORCE extends high performance RTM process capability and is equipped with an internal mold release package, minimizing external mold release application costs. Furthermore, it is designed to be non-aggressive toward high performance RTM equipment to prevent corrosion issues associated with other chemistries.

This epoxy resin system has proven to be a break-through technology, which truly enables mass production, allowing production rates of up to 100,000 units/year for RTM and up to

300,000 units/year for wet compression, allowing a reduction in part costs and production costs of carbon fiber reinforced plastic (CFRP) parts as compared to metal alternatives. The low viscosity of the developed product coupled with a good latency can help to realize large, integrated complex RTM components, a vital element for cost effective carbon fiber composite parts. This mass production system integrates a release functionality which does not affect downstream assembly processes, such as bonding, which is a preferred assembly solution for CFRP.

In addition, Dow has cooperated with tiers that provide carbon fiber textile solutions, such as Voith, who bring further production efficiencies by limiting fiber waste in the preform process. Early efforts demonstrate how the combination of resin and fiber technology together can establish a lightweight material as a material truly fit for mass production by offsetting the material costs through process and production benefits.

Conclusion

The on-going drive for improvements in vehicle fuel economy continues to spur new innovation in a wide array of vehicle technologies with vehicle mass reduction considered a critical element to achieving this goal. The latter has prompted further interest in lightweight body and chassis systems that take advantage of advances in materials such as high strength steel, light metals and composites.

This report summarized the joint efforts of Dow and its OEM and Tier 1 partners on the development and implementation of novel carbon fiber composite solutions combining state-of-the-art resin technology with latest fiber processing technology. By achieving an economically compatible way of producing carbon fiber parts, the described developments for RTM and prepreg applications validate the use of carbon fibers as technical and economically validated material in lightweight design for high volume vehicles.

Acknowledgement

The authors acknowledge the leadership of Patrick Blanchard and Jeff Dahl from the Ford Motor Company Research and Innovation Group. Their vision and commitment to the joint development agreement was critical for our diverse team to be successful.

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FEATURE

Production of thermoplastic compound materials for processing by injection molding, blow molding and extrusion

Mikhail Katsevman, Alexander Pavlov, Pavel Kruglov

R&P Polyplastic, Russia
TH Polyplastic, Russia

R&P Polyplastic specializes in the production of thermoplastic compound materials for processing by injection molding, blow molding and extrusion. Working at the intersection of science, technology and business, we are committed to knowledge, respect the facts and are completely dedicated to our business. Sharing the global values of the 21st century, R&P POLYPLASTIC responsibly transforms them into real actions, subordinating its commercial, production and corporate processes to the idea of sustainable development.

Development of the future Russian leader of polymer compound materials market began with its registration on August 19, 1991 — day one of the August putsch and the beginning of the fall of the Soviet Union. Against the backdrop of the general recession of domestic industry at that time, and after careful analysis of the situation, the management made a risky but wise decision — to organize its own production of polymer compound materials with a wide range of application properties(see Figure 1).

1991 – new company in a "new country

As a result of hard work of the whole team, in an environment of the country's severe economic crisis, the first 240 tons of compounds were manufactured on leased equipment at the Kuskovsky plastics plant — and successfully sold afterward. That year, R&P POLYPLASTIC confidently carved out its niche on the Russian market of polymer materials. The company fostered close cooperation with numerous partners, such as industrial enterprises in Russia, Belarus, Kazakhstan, Ukraine, and the Baltics — many of them were able to continue production due to R&P POLYPLASTIC's assistance (see Figure 2).

In 1994, the company's first trademarks have been registered: ARMLEN® (polypropylene based compound) and ARMAMID® (polyamide-6 based compound). The range of glass-reinforced and mineral-filled compounds will amount to 12 brands by the end of the year. More than 1000 tons of finished products were shipped. R&P POLYPLASTIC was able to increase production since then year by year and in 2016 has reached production capacity of 110,000 tons (see Figure 3).

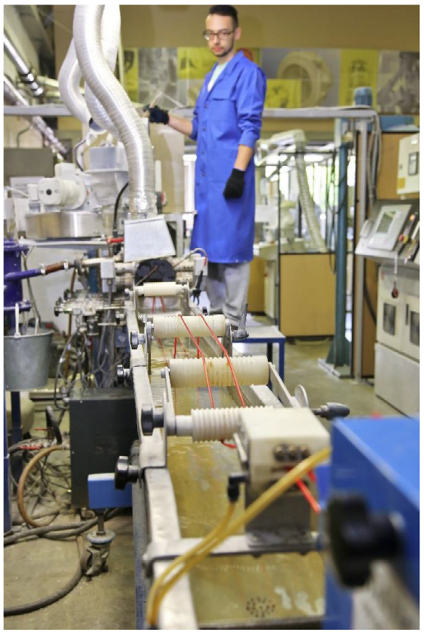

FIGURE 1
Research and Development Centre.

By 2008, the brand range had been expanded to a degree that allowed the company to rise to the global level: POLYPLASTIC

FIGURE 2
Plant in Engels, compounding process.

FIGURE 3
Research and Development Centre.

became a supplier for most international plastics processing companies in Russia. Active measures were undertaken to localize the compounds utilized in production of auto parts for many foreign car manufacturers and system suppliers launching plants in Russia. Large-scale projects for the development of materials for the construction industry were launched. After the outbreak of the 2008 global financial crisis, the company found itself among the lucky few with gross losses of only 22–23% (see Figure 4).

Our achievement – the millionth ton of compounds

In 2016 R&P POLYPLASTIC celebrated its 25th anniversary and entered a new era – the company has crossed the one million threshold in production. On 24th of November, Togliatti plant presented the millionth ton of compound materials. Among those who came to applaud the plant's team were top-managers of strategic company-partners, representatives of local authorities and the industry's scientific community. The journey to one million had begun a quarter of a century before. POLYPLASTIC collaborated with such world auto concerns as Renault-Nissan-AVTOVAZ, Ford, Peugeot-Citroen, GM and Russian manufactures – GAZ, KAMAZ, UAZ and in fact the

FIGURE 4
Armamid, Polyamide based compound.

anniversary ton was shipped to AVTOVAZ – the countries' largest automobile manufacturer warehouse (see Figure 5).

Nowadays the structure of R&P POLYPLASTIC consists of the head office located in Moscow, two production sites and an R&D center with pilot production. The industrial sites are located in the Russian regions. The first production plant is situated in the auto capital Togliatti (Samara region) geographically aiming at one of our main customers – Renault-Nissan-AVTOVAZ. Another larger plant is located in Engels (Saratov region). There are 13 production lines of world-renowned producers of equipment such as BUSS, Berstorf, Coperion, and ICMA. By the end of 2017, there are plans to launch two additional extrusion lines allowing to increase production capacity to 115,000 tons a year (see Figure 6).

At present, our company's corporate profile is the production of thermoplastic compound materials, which are widely used in various industry sectors and areas of human vital activities. The major customers of R&P POLYPLASTIC are auto industry companies, large domestic appliances makers and manufacturers of construction materials both interior and exterior. We have a wide range of materials, more than 250 product grades primarily based on Polypropylene (Armlen) and Polyamide (Armamid). There is also quite high demand in Russia for our products based on PA66, HDPE, PBT and POM under brand names Technamid, Armobond,

FIGURE 5
Testing laboratory.

FIGURE 6
Compounds samples.

Torlen, Technoter, Technoset and others. We also have new developments based on polyphenylene sulfide — a material adapted to high temperatures and used in energy industry.

Our list of products includes Armlen, Armovil, Technamid, Armoflen, Technoset, Technotep, Technoter, Armobond and Torlen. Now some of them are discussed more closely.

ARMAMID is a filled and modified compound on the basis of polyamide-6 (PA-6). PA-6 — most popular constructional thermolayer in Russia, widely applied in compounding. The scope of its application is wider than that of other engineering plastics and is determined not only by the set of its properties (high oil and gasoline resistance, resistance to hydrocarbon products, mechanical durability and rigidity, high shock resistance, heat resistance and anti-friction properties), but also by its availability as it is produced in Russia from domestic raw materials. The shortcoming of the material is its rather high moisture absorption, which limits its application in humid environments for the production of precision products.

ARMLEN is a filled and modified compound based on polypropylene. This material belongs to the polyolefin class (polypropylene), it is most suitable for subsequent compounding to derive a number of affordable thermoplastic materials with unique mechanical properties. Materials of the ARMLEN line share the advantages of a polypropylene matrix (the lowest density of all plastics, low moisture absorption, affordability, easy to process, chemical resistance) in combination with various functional fillers (fiberglass, mineral fillers, antipyrenes, shock-resistance modifiers, and others). ARMLEN application is particularly wide in such areas as the automotive industry, mechanical engineering household appliances, electrical equipment, construction, pipe production.

ARMOVIL (PVC) is a polyvinyl-chloride-based compound. This material has a number of unique qualities and is highly resistant to acids, alkalis, alcohols, mineral oils, swells and dissolves in ethers, ketones, chlorinated and aromatic hydrocarbons.

Compound materials based on plasticized PVC can be used for the production of: floor covering (PVC dale); cushions for railway transport; pseudo-rubber parts for sealing and shock-absorption; sealants for plastic windows; sealants for household appliances.

TECHNAMID is a polyamide-66-based, filled compound. It combines high mechanical performance and elasticity across a wide range of temperatures, anti-friction properties, high fatigue resistance and low creep flow. Material has excellent oil and benzine resistance and resistance to hydrocarbon products. Properties of PA-66 resemble those of PA-6, the main difference is higher heat resistance and lower moisture absorption.

TECHNOTER is a filled and modified compound based on polybutylene terephthalate. Application of polybutylene terephthalate (PBT) and compounds on its basis has actively expanded over the last 10 years. This growth was triggered by their successful use in electrical equipment and electronics. Materials of the TECHNOTER line employ valuable qualities of the matrix (high mechanical durability, heat resistance, excellent dielectric properties, including at elevated temperatures and humidity, spark stability, the highest dimensional stability among thermoplastics, including in humid environments) which, when combined with various fillers and modifiers, yield a wide range of compounds.

R&P POLYPLASTIC – a customer focused company

The most perspective industry sector for the company today is auto industry. Each vehicle contains more than 10% of thermoplastic compounds and this rate is constantly growing. However, we pay attention to all of our clients' needs and try to find an individual approach to everyone. For instance, when one of our clients – Whirlpool – asked to work out an individual solution to developing a washing machine's drum for their latest model our specialists in cooperation with Owens Corning managed to successfully cope with this task and develop a material enabling to make sides of the drum thinner nevertheless leaving the same strength characteristics. This allowed to increase washing machine drum's efficiency up to 30% and spin cycle speed to 1500 rpm without changing its dimensions. In 2014 we were honored the JEC international award for this achievement.

According to the analysis, the automotive industry remains to be a leader in the company's solutions list: 32% of POLYPLASTIC's compounds were delivered to production sites of this industry. Household appliances stand second in the ranking of supplies with a number of 26% from the total amount of materials delivered. This was made possible through a major breakthrough accomplished by the Research and Production enterprise – in 2016 the company signed a partnership agreement with a world leader in white goods Samsung. Construction follows with 17% from the total capacity.

In 2017 R&P POLYPLASTIC compound materials were included in the PMR 2017 international list of French car manufacturer PSA Peugeot Citroen whose production lines are located in European countries, Latin America, Turkey, Russia, China and Morocco. This means that Russian compounds which were tested in French, German and Russian laboratories may be used for car spare parts of domestic and foreign origin. The list included 11 POLYPLASTIC's grades.

Our company has already achieved considerable results on the local market and now we are seeking new ways for development. Our strategy for the nearest future is to actively develop the business in Central Europe and Eastern Europe. Most of our potential customers are located in this region. We are quite confident in our success because various international manufacturers homologated our materials. Therefore, they can be used at pro-

duction plants of an international car manufacturer around the globe. In 2017 the company started an expansion program of external development "Export boost" choosing the extensive path based on the principle of mergers and acquisitions. Our company is ready to cooperate in any forms including purchasing new production plants. The priority form of expansion is integration with large-scale producers in Central Europe.

Targeting new markets – the launch of "export boost program

Our enterprise has been successfully delivering its mission for more than a quarter of a century. We have been working with some of our suppliers for decades. On Polypropylene and Polyamide, our basic matrices, we are working with local producers such as Sibur, Lukoil, Nizsnekamskneftehim, Kuibishevazot and others. Our company prefers to build long-term relations with all our suppliers. Today our company is looking forward to the opening by Zapsibneftehim (belongs to the Sibur Group) of the largest modern petrochemicla complex in Russia with a PP copolymer production unit with 500 thousand tons capacity. The installation of this unit will give our company a competitive advantage, most probably not only in Russia but also in the whole post-soviet region.

Talking about R&D and our advanced projects today there is a development trend of compounds based on high-temperature matrixes including the use of high modulus and so called long fibers (LFT) in order to achieve a unique range of characteristics. These materials are increasingly used in electronics, electric engineering, auto industry and other high-tech industries as an alternative to metals. We also expand the use of recycled polymers and biodegradable compounds. We are actively working in these directions. Our R&D specialists have developed a relevant compound product range.

R&D – the future of the company

A separate group of developers is working with recycled polymers. They analyze the market, conduct experiments, develop formulations and create quality requirements for future industrial application.

We are quite optimistic about our future. Next year we are planning to take part in a number of international exhibitions such as the Moscow-hosted Interplastica or the largest world compound exhibition Compound World Expo 2018 in Germany. It will be the first time for us to participate in this large international event. Compounding World Expo will take place at Messe Essen and we are looking forward to this as an opportunity to meet new customers and make our company more recognized at the international level.

Last year R&P POLYPLASTIC had its 25th anniversary. Remarkably, our company was registered at the day, which became a turning point for our country – the collapse of the Soviet Union and the foundation of a new Russia. And believe me, a quarter century's development of a company that is 100% private through such a difficult period is worth a lot.

ELSEVIER

FEATURE

Complete high-end LFT system produces fully biodegradable LGF compounds

Oliver Eitel [a], Timo Lehtonen [b], Tomi Kangas [b]

[a] Coperion, Stuttgart, Germany
[b] Arctic Biomaterials Oy LTD,Tampere, Finland

Finnish startup Arctic Biomaterials uses biodegradable long glass fibers to produce high performance biocomposites for use as a sustainable alternative to conventional LFTs for demanding engineering applications. Coperion has supplied Arctic Biomaterials with a complete turnkey system for the purpose (covering everything from unreeling roving and conveying materials to bagging), using their own components together with others supplied by a partner. Since the system was commissioned in mid-2016, pilot production has been running with the desired high flexibility and efficiency.

The Finnish city of Tampere, in Europe's far north, has been home since 2014 to a company which produces bioplastics compounds with increasing commercial success. On first hearing, this sounds rather run-of-the-mill, but in fact Arctic Biomaterials (ABM) has carved out for itself a very special niche: They use biodegradable glass fibers to reinforce thermoplastics which are likewise biodegradable and are completely or partially biobased.

Since starting materials development, ABM has responded to what is a clearly significant demand across various industrial sectors to arrive at an extensive product portfolio. At the time of printing, this portfolio already encompasses over twenty different grades of bioplastics compounds for use as sustainable alternatives in demanding engineering applications. Eight of these are reinforced with biodegradable long glass fibers.

Biodegradable glass fibers

Conventional glass is one of the most durable materials known to man. As filaments just a few micrometers thick, it is a highly effective additive in both mechanical and economic terms, imparting greater strength, rigidity and impact resistance to plastics, increasing their heat resistance and dimensional stability and reducing distortion. In biodegradable compounds, however, conventional glass has a negative environmental impact.

ABM offers a solution here in the form of glass fibers which, like the plastic matrix, degrades and dissolves down after use into environmentally compatible constituents. Originally these fibers were developed to provide medical materials which were harmless to health and their formulation corresponds largely to that of conventional E-glass. Modifications made by ABM have ensured that these glass fibers meet the plastics industry's application and processing requirements. The other properties typical of E-glass have been retained. In practice, this type of reinforcing glass fiber only starts to degrade when the original protective (impregnating) biopolymer breaks down. Ultimately, all that is left over is basically minerals.

Biobased LFT compounds

The biodegradable glass fiber rovings, produced in-house by the company, are currently still used exclusively by ABM to produce their own short and long fiber-reinforced compounds. LFT grades for engineering applications (trade name: ArcBiox) are produced by thermoplastic pultrusion. This involves separating the individual fibers of the rovings and then completely enclosing them in a thermoplastic matrix by pulling them through a multi-hole die together with the polymer, which has been melted and had additives incorporated in an extruder. The final step is chopping to the desired length.

For this type of production, ABM's research and development department uses any commercially available biopolymers, i.e. both (partially) biobased and biodegradable grades, including polylactic acid (PLA), polyhydroxybutyrate (PHB) and polybutylene succinate (PBS), depending on the requirements of the particular application or customer. ABM also primarily trials

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TABLE 1

ABM's portfolio of biodegradable glass fiber-reinforced engineering compounds.

Grade	GF type	Matrix	Flexural strength, MPa	Flexural modulus, MPa	Notched impact strength, 23 °C, kJ/m²	Heat resistance, °C
BGF-30-A1	Long	PLA	212	10,400	10	160
BGF-40-A1	Long	PLA	215	14,500	12	160
BGF-30G	Long	PBS[1]	117	4940	19	112
BGF-30-B1	Long	PLA	140	10,400	16	124
SGF15-A1	Short	PLA	170	7200	11	135

[1] Polybutylene succinate.

FIGURE 1

Components for automotive interior, consumer electronics and rigid packaging are among the typical applications for biopolymers reinforced with biodegradable glass fibers.

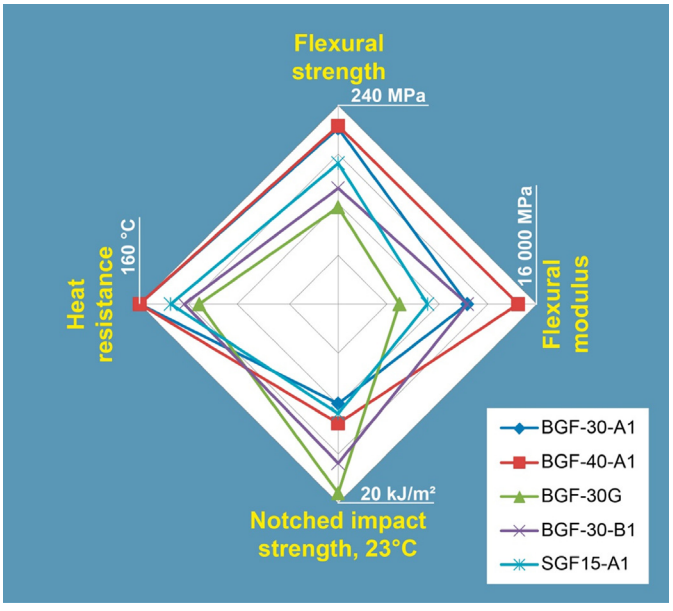

FIGURE 2

Tensile strength and stiffness, notched impact strength and HDT of the fiber-reinforced grades in the ArcBiox product range.

biobased products when selecting additives, for example for coloring purposes or as flame or UV protection.

The ArcBiox family's BGF grades shown in Table 1 are available for initial commercial applications and customer testing and they all combine high rigidity with good notched impact strength (Figure 2). Due to their very high thermal stability (HDT/A) of up to 160 °C, compared with around 60 °C for the corresponding unreinforced grade, the LFT grades open the way to using biopolymers in applications involving severe thermal stress. In the automotive industry, such applications include interior and under-bonnet components where biobased or biodegradable compounds must offer the same mechanical properties and thermal stability as conventional engineering polymers. Other typical fields of application are the electrical and electronics industries as well as furniture, domestic appliances or toys (Figure 1), indeed basically all areas in which manufacturers want to step up the use of renewable resources and sustainable solutions.

ABM's portfolio additionally includes a short glass fiber-reinforced, PLA-based SGF grade (also included in Table 1) and a range of unreinforced grades. These unreinforced grades include PLA-based compounds and nano-compounds which can be used to replace SAN, PP or ABS in certain applications, and a PC+ polyester-based grade offering an alternative to conventional PC/ABS blends.

Turnkey system

Coperion has recently expanded its long fiber technology offer in Europe and Asia and, in cooperation with a partner, now offers complete systems with optimized components for manufacturing LFT, which is seeing growth in demand. It therefore made sense for ABM to turn to Coperion in its search for a turnkey offer of this type. The specification for the planned pilot plant included not only reliable operation of the overall system but also maximum flexibility with regard to formulation and to production parameter monitoring and documentability. The target value set by ABM for the production of PLA LGF30 (PLA with 30% b.wt. long glass fibers) was a minimum throughput of around 120 kg/h when using 1200 tex rovings.

Coperion took up this challenge and, working closely with its client, took just twelve months to configure, build, install and commission a complete system. This high-end LFT system (Figure 3) currently in use by ABM consists of the following individual components:

- dryer and conveying system for the bioplastics and the additive/masterbatch pellets

FIGURE 3

Overview of complete LFT system supplied to ABM by Coperion.

- gravimetric feeding system for these components, S60 single screw feeder with 50 liter hopper plus 3 × KT20 twin screw feeders with 20 liter hoppers (manufacturer: Coperion K-Tron)
- creel rack (32 strands) with turn tables
- ZSK 26 Mc^{18} twin screw laboratory extruder (26 mm screw diameter, P = 37 kW) with twin screw side feeder ZS-B 25 for additive/masterbatch addition (manufacturer: Coperion)
- roving preheater and tensioner
- 32 strand impregnation die head
- water bath and LFT strand calibration
- LFT strand puller with rotating bobbins
- LFT pelletizer with cutting rotor for pellet lengths of 4–12 mm (manufacturer: Coperion Pelletizing Technology)
- LFT classifying screen
- optional: strand pelletizing system for non-LFT compounds (manufacturer: Coperion Pelletizing Technology)
- finished product handling system including dry air conveying system and filling hopper (4 m^3) (manufacturer: Coperion and a partner)
- semi-automatic bagging machine

Coperion K-Tron's gravimetric feeders (Figure 4), Coperion's ZSK 26 Mc^{18} co-rotating twin screw compounding extruder

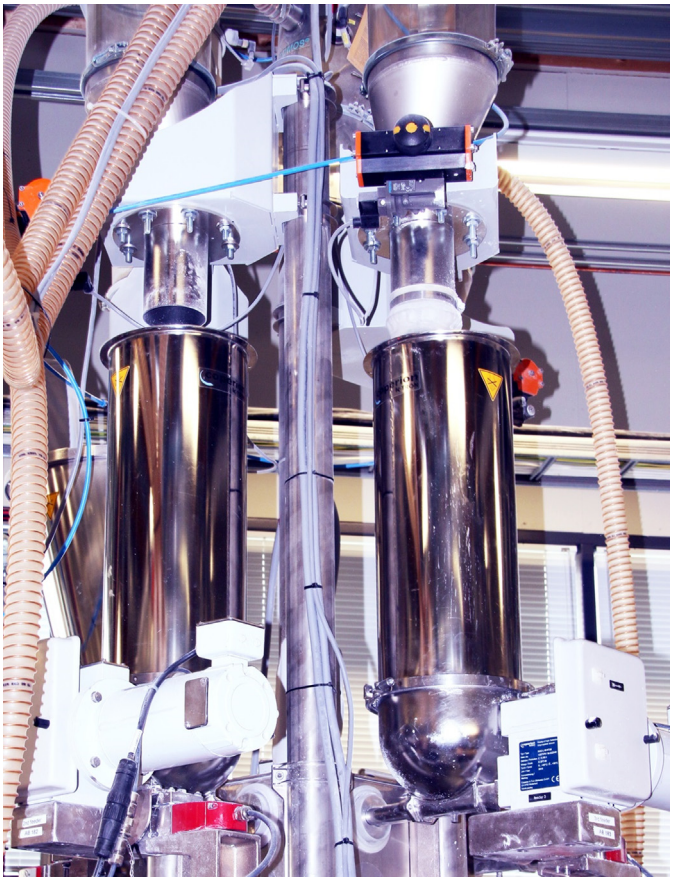

FIGURE 4

Accurate and adjustable feeding of the additives, some in powder form, in ABM's system is ensured in part by three KT20 gravimetric feeders with 20 liter hoppers (manufacturer: Coperion K-Tron).

(Figure 5) and the coupled 32 strand LFT pultrusion system (Figure 6) are the linchpins of the overall system. With gravimetric feeders raw materials such as polymers and additive powders as well as fillers such as talcum and chalk can be fed accurately according to the desired formulation, and the composition of the plastics compound can be very flexibly adapted to specific product requirements.

With this and the upstream dryers and dry air conveying of the end product, the LFT system used by ABM offers outstanding versatility for developing new formulations and producing sample batches. All the components are ideally matched, the fibers are wetted very gently, and thermal degradation of PLA is effectively prevented. This and the dry packaging of the resultant PLA-GLF rod-shaped pellets (Figure 7) ultimately results in very high product quality, the pilot plant so allowing largely problem-free upscaling to an industrial scale.

High feed accuracy enables thrifty use of high-quality additives

The load cells in the gravimetric feeders use Coperion K-Tron's own patented Smart Force Transducer technology. Measurement based on the vibrating wire principle is performed continuously and with a resolution of 1:4 million in 80 ms. This state-of-the-art technology requires no calibration and uses a dynamic

FIGURE 5

Coperion's ZSK 26 Mc[18] co-rotating twin screw compounding extruder is specifically optimized for product development tasks.

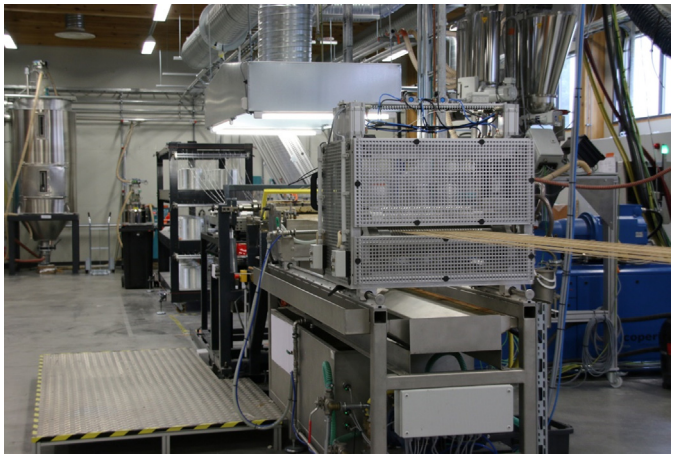

FIGURE 6

Together, the 32 strand pultrusion system and the twin screw extruder ensure the specified productivity is achieved.

FIGURE 7

ABM's biobased compounds include rod-shaped long fiber reinforced pellets.

algorithm to filter out extraneous vibrations and shocks even under difficult operating conditions. Excluding ambient influences in this way means that the weigh module always yields accurate information about the actual weighing operation. As a result, a more compact, lighter and more cost-efficient feeder configuration is possible, which is more suitable for mounting directly on the extruder body.

Gravimetric feeding of ingredients also ensures high accuracy, even at very short feed intervals of often just a few seconds. In order to ensure that this is the case even in critical applications, the system can perform up to 112 measurements and twelve associated adjustments per second, thus enabling thrifty use of costly, high-quality additives and doing away with deliberate overfeeding to ensure the minimum required additive content.

During the feeding cycle (descending curve in the diagram in Figure 8), the Screw Speed Modulation algorithm developed by Coperion K-Tron ensures steady discharge. To this end, it records mass flow pulsation, which often occurs within one screw revolution in the case of slow-running single screw feeders, and proactively adjusts screw speed accordingly, to compensate for this undesired effect. The operator then has an actual usable feed range of 100:1, without the need to make any changes of any kind, even in an ATEX category 3D explosive environment.

During refill of a loss-in-weight feeder hopper (ascending curve in the diagram in Figure 8), measured weight is not helpful in controlling feed rate. Conventional systems keep screw speed constant until this operation is complete, resulting in sometimes major feed inaccuracies during filling and the subsequent transient control response (red curves in Figure 9). In contrast, Coperion K-Tron's exclusive Smart Refill technology stores the screw speed measured for the respective fill level (the respective hopper weight) during hopper emptying and then adjusts this accordingly during refilling to compensate for the associated continuous increase in material density. In this way, the required feeding performance is accurately maintained and the transition to gravimetric monitoring is smoother (blue curve in Figure 9).

In addition to the major gain in feeding accuracy, this technology also leads to moderate purchase and installation costs, since it allows more frequent refilling without impairing product

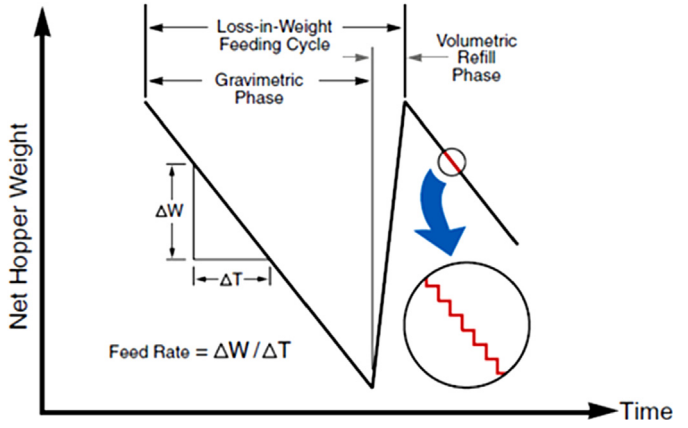

FIGURE 8

Change in hopper weight of the gravimetric feeder unit during emptying and refilling.

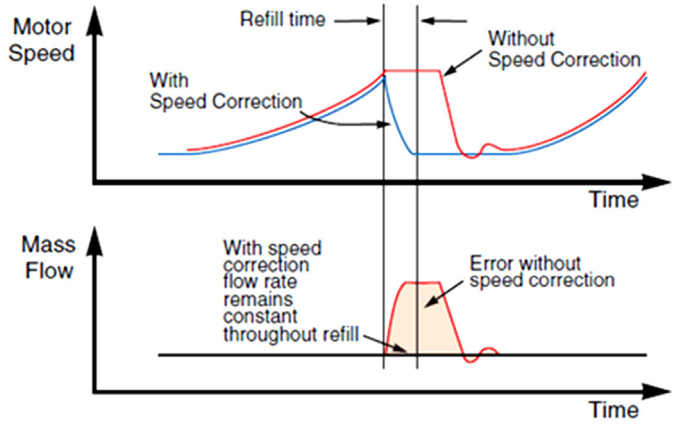

FIGURE 9

Comparison of conventional control during refilling (red curve) with Coperion K-Tron's Smart Refill technology (blue curve).

quality so that lower capacity hoppers can be used. These in turn allow the use of smaller load cells and thus increased accuracy. In addition, this specific refilling algorithm enables trouble-free, capacity operation of the extruder, ultimately resulting in higher extruder throughputs.

Compact laboratory extruder gives flexibility

The ZSK 26 Mc^{18} is a compact, mobile laboratory extruder with ready-to-use installed heating and cooling. With its 26 mm screw diameter, Coperion has designed it specifically for developing formulations and producing sample compounds and small compound quantities of up to around 180 kg/h (Figure 10). The ZSK 26 Mc^{18} is particularly suitable for compounding engineering plastics, as its high torque, typical of the entire ZSK Mc^{18} range, allows a high screw filling level and hence gentle, energy-saving processing and a correspondingly low melt temperature. At the same time, the extruder is capable of achieving the high throughput for supplying the 32 strand system, so meeting the customer's throughput requirements. The mobile undercarriage of ABM's pilot plant opens the way to a changeover from operation

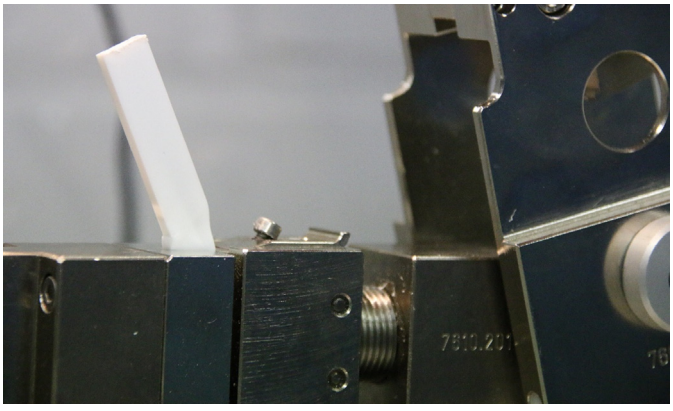

FIGURE 10

The ZSK 26 Mc^{18} is specifically designed for developing formulations and producing sample compounds and small compound quantities.

in conjunction with the LFT pultrusion line to the conventional compounding line if additive masterbatches or specific PLA compounds are to be manufactured.

Predestined for growth

Both the increasing use of light but high performance plastics parts in demanding engineering applications and the growing desire on the part of both OEMs and end consumers to protect the environment by using sustainable materials, would suggest biobased compounds are destined for strong growth. According to a European Bioplastics study published in 2016, the global production capacities for this class of materials will grow by app. 40% over the next four years. ABM is ready for this growth and is planning, for example, to expand manufacture of biodegradable glass fibers, currently still based at a pilot plant on the Tampere site, to Tianjing China, where a new industrial-scale plant will be installed for this purpose. “The new production facility in Asia has been designed for maximum capacity of 30 kt of composite material. Investments will be made step by step based on business cases”, says Tomi Kangas, Sales and Marketing Director at ABM.

Alongside further projects relating to the production of rod-shaped LFT pellets, Coperion has in the meantime also supplied the three system component materials conveying, feed and compounding extruder for three production lines for producing UD tapes. Coperion is also working with partners to offer complete production lines for this sector.

Arctic Biomaterials Oy

Arctic Biomaterials Oy is a startup company set up in 2014 to produce biodegradable plastics compounds for biomedical (Evolvemer™ and Evolvecomp™) and engineering (ArcBiox™) applications. Both product families use biodegradable glass fibers produced using ABM's own ABMcomposite technology. Virtually all of ABM's 23 current employees combine Research & Development roles with production-related activities. ABM's present production capacity for LFT pellets and biocompounds is up to 120 kg/h each.

ELSEVIER

Continuous-length +/−45 spread tow fabrics reducing knockdown factor for bias reinforcements

FEATURE

Fredrik Ohlsson

Spread Tow fabrics have already proven to offer reduced weight, increased stiffness and strength, improved impact as well as better dampening performance of composites parts and can be highly tailored to meet specific needs. By offering continuous length +/−45 fabrics in up to 60″ (1524 mm) width, the construction freedom is highly broadened.

Thinner ply layup is possible to utilize as the transition from handling, sometimes flimsy, thin UD plies in bias angles to stable and symmetrically balanced +/−45 fabrics, allow for full handle ability and reduced number of plies needed.

The material presents a +/−45 ply with truly the same properties in +45 and −45. Also, the need for splicing and joints generating thickness variations at large parts and the economically important labor saving and reduced scrap material level associated with bias cutting edge triangle waste are eliminated compared to use of traditional 0/90 and UD reinforcements.

Furthermore, the +/−45 Spread Tow fabric is stable to handle and to prepreg in normal hot melt lines without skewing.

More importantly, Spread Tow +/−45 does not include any stitching or fixation yarn. This minimizes the risk of mechanical issues such as micro cracks but also the difficulty in predicting its mechanical performance due to the induced geometrical variation the stitching or stabilizing/fixation yarns normally give in the meso structure.

Spread Tow reinforcements have been available on the market for many years now. Following its early adopter applications in motor racing and sports & leisure where Spread Tow reinforcements have allowed weight savings from customized products to mass production volumes, now making their way into new industries such as industrial and aerospace applications.

The uniqueness and outperformance of Spread tow material were initially associated with its reduced fiber crimp angle and frequency [1] thereby closing the big gap in utilization of the fibers' performance between unidirectional tapes (UD) and traditional yarn woven fabrics, Spread Tow fabrics proving 20% higher performance than the traditional yarn woven fabrics. This achievement, together with the ability to realize low areal weight reinforcements below those of woven 1 k cloth, while using more economic and readily available heavy tows (12 k and above) and higher performing fibers, (e.g. intermediate and high modulus fibers rather than the standard high strength 1 k fiber) provided new design possibilities for laminates.

Traditional composites have been additionally challenged by the inherent ability of Spread Tow fabrics to delay (or suppress) the initiation of transverse matrix cracks in the laminate because of its relatively wide spread tape width and subsequently thin ply thickness [2]. The ability to withstand transverse matrix cracking highly depends on the ply thickness, as already studied by Parvizi in 1978 [3,4].

The increased use of composite materials has enlarged the variety of designs and increased the demands on better performance and better utilization of material. While continuous production and repeatability of a product performance is being requested by the industry, +/−45 oriented fabrics have become essential for many applications.

Continuous-length +/−45 spread tow fabrics

The development and offer of continuous-length +/−45 Spread Tow fabrics in 2011 [5] has provided unique possibilities in utilizing reinforcement materials with tailored performance to meet specific applications. The following sections will further describe how these materials can be implemented for economical and performance solutions.

Waste reduction at bias cuts

The plies orientation and thickness distribution in a composite part is highly defined by how this is loaded and how it is designed to respond to that stress condition. For structures subjected to torsional forces, fiber plies in +/−45 degrees, in reference to the main load direction, are commonly utilized. This is

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also the case of the very much preferred quasi-isotropic lay-up where +/−45-degree plies are combined with 0/90-degree oriented reinforcements to allow for symmetrical and well-balanced laminates.

As UD reinforcements and woven fabrics are traditionally produced in 0 degree and 0/90 degrees respectively, many applications force to cut the needed +/−45 patches diagonally from the rolls of the first. In some cases, when the size of the plies is larger than what could be cut bias from the 0 or 0/90 material roll, two or more patches have to be spliced together at layup. Typical examples are wing skins for airplanes fixed wings for sail boats (such as for the Americas Cup catamarans). However, in many applications where rectangular patches are required in +/−45 degrees orientation or diagonal splicing is not allowed the waste level associated with edge triangles can increase greatly depending on the patch dimension as can be seen in Figure 1.

The following Eq. (1), shows the waste ratio resulting from a 0 or 0/90 fabric/reinforcement of width W_f when a +/−45 patch of width W_p is cut from it.

$$Waste = \frac{W_p}{\sqrt{2}W_f - W_p} \quad (1)$$

A plot in Figure 2 of the waste percentage over patch width for three typical fabric roll widths, 1 m (40″), 1.25 m (50″) and 1.65 m (60″), clearly shows how a wider fabric roll reduces the waste ratio for bias cuts. It is also clear that the maximum patch length for each roll width is limited by the corresponding fabric diagonal. The maximum theoretical waste of 50%, occurs when the width and the length of the patch are equal, e.g. when a quadratic square patch needs to be cut.

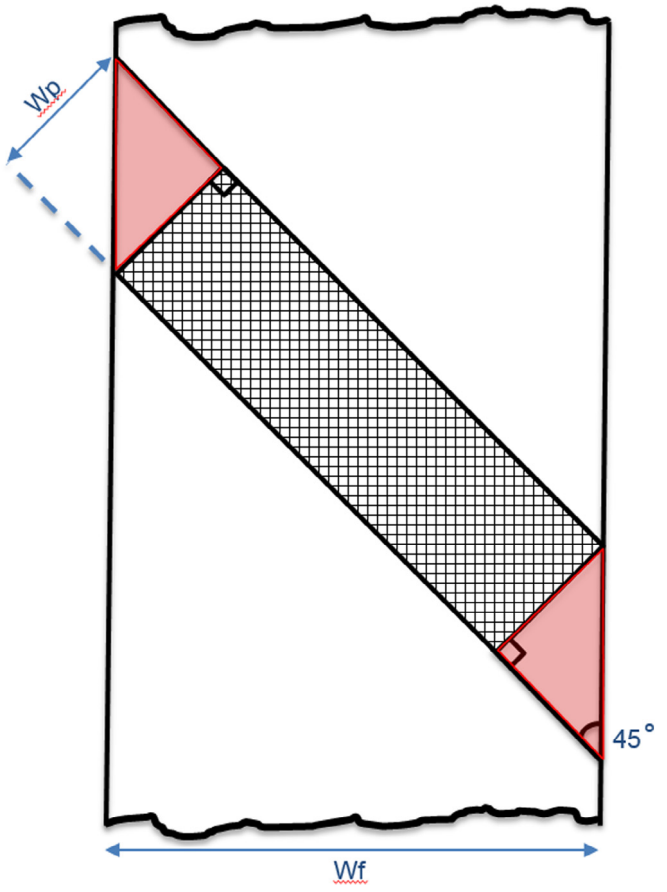

FIGURE 1

Schematic of edge triangle waste for bias cut Wp wide patches from a Wf wide fabric.

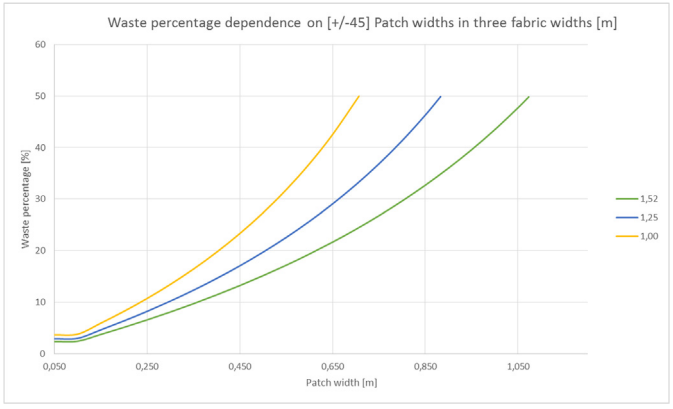

FIGURE 2

Waste percentage over patch width for three fabric roll widths [m] for bias patches.

Using continuous-length +/−45 Spread Tow fabrics, Figure 3, the waste associated with the edge triangles can be highly reduced. Rectangular patches with fiber angles in +/−45 can be cut with essentially no waste.

Prepregging of +/−45 reinforcements

The availability of reinforcements with +/−45 fiber orientations is not new on the market. Braided materials have allowed this disposition of the fibers by cutting tubular preform, thus obtaining flat bi-directional +/−45 reinforcements similar to the continuous-length +/−45 Spread Tow fabrics. Such materials have also allowed reduced waste levels associated with edge triangles in bias cutting. However, braided reinforcements are produced using traditional circular yarns and its stability is highly dependent on the geometrical locking between the yarns. This characteristic together with the absence of lengthwise running load carrying fibers when produced makes the braided +/−45 material difficult to handle, especially in downstream operations

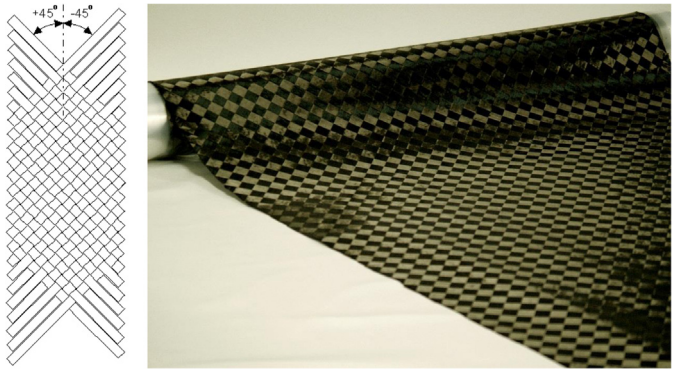

FIGURE 3

Continuous-length +/−45 Spread Tow fabrics can allow the waste associated with the edge triangles for bias cuts to be highly reduced. Schematic view on the left and real material roll on the right.

such as prepregging in which the loose material can skew and it fiber angles divert from the intentional +/−45.

This has been solved in various ways in the products available on the market. Some reinforcements are equipped with a melt bonded thermoplastic thread running along the lengthwise direction to improve its handling. Other materials require a support paper in direct contact which the otherwise sensitive and unstable reinforcement material. In this case the support paper bares all the longitudinal loading during its processing.

In addition to cut open braids, stitched materials such as non-crimp fabrics (NCF) also present continuous +/−45 reinforcements. These NCF materials can reduce the bias cut edge triangles in a similar way as the cut open braids while making use of stitching threads that increase the longitudinal stability of the reinforcement, what enables it to be pulled through a prepreg line without skewing.

This stitching thread does however not only bring the positive stability functions to the reinforcement but can negatively affect the mechanical performance of the composite structure due to the CTE (coefficient of thermal expansion) mismatch between the standard thermoplastic stitching thread and the often-used thermoset matrix system, inducing a risk for the creation of matrix cracking and possible composite failure. This phenomenon can also occur in the braided reinforcements when these are stabilized with thermoplastic threads.

In the case of a continuous-length +/−45 Spread Tow fabric the woven reinforcement relies its stability on its binder stabilized Spread Tow tapes. This binder prevents the spread tows from contracting back to the original yarn shape during the weaving process. Furthermore, the slightly tacky binder provides some adhesion between the +45 and −45 tapes in the fabric. The presence of the binder together with the interlacing of the tapes in plain weave patterns creates a shear lock effect that allows the fabric to be pulled through prepreg lines.

Variance in performance

While the stitching threads allow NCF materials to be prepregged they can cause other sever issues. The +45 and −45 fiber layers in a NCF material are held together by the stitching thread passing up and down though the reinforcement. Because of its pattern the thread tends to bundle the fibers, causing undulations/waviness, fiber crimp, fiber knees or kinks in the reinforcement both in and out of plane. During a tensile loading the fibers will be able to transfer the load despite these knees or kinks and the structure will display typical failure mechanisms such as transverse matrix cracks, matrix crack induced delamination, free edge delamination and finally fiber failure. However, in under compression forces, failure mechanisms can either occur within a fiber, in the matrix or at the interface between the fiber and matrix. A laminate loaded in compression usually experience failure mechanism such as kink-band formation, fiber failure, splitting, buckle delamination, elastic micro buckling and shear-band formation [6]. Kink-band formation is commonly defined as the angle misalignment between the normal plane and the rotated section, as can be seen in Figure 4. These undulations apparent in the composite laminate can affect to a great extent the compression strength of a structure. An increase in

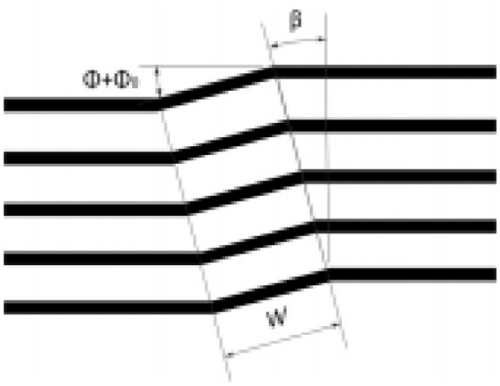

FIGURE 4

Definition of the geometric parameters for a kink-band.

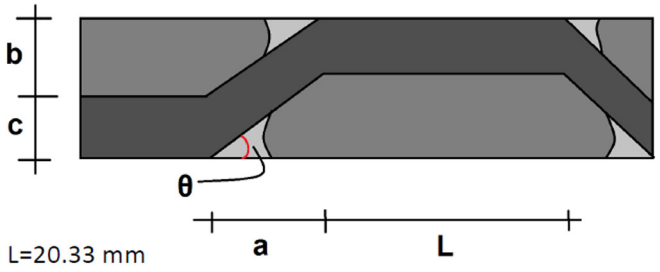

FIGURE 5

Schematic view of a Spread Tow Fabric interlacing structure where L = 20,3 mm, a = 1,7 mm, c and b = 70 μm, θ = 2,5°.

the out of plane waviness by a factor of two, reduced the compression strength to half [7].

When studying the differences between compression and tensile strength in a material the ratio X_C/X_T can be defined. Typically, NCF materials show a ratio of 0,4 (compression strength being just 40% of the tensile strength) while UD reinforcements present 0,7 [7]. Spread Tow fabrics have no apparent undulations and due to the lack of stitching threads minimize amount of fiber kinks. In Figure 5 a schematic view of a Spread Tow structure is shown. The undulation angel θ presents relatively low values and the distribution of the out of plane waviness is focused to a very short length.

From twelve different test results on Spread Tow fabric laminates a ratio X_C/X_T of 0,7 (average) was determined, showing similarities in performance to UD reinforcements still using a woven construction. These tests were conducted according to mainly AITM 1-0007 i3 and AITM 1-0008 i7, BS ISO 527-4 and PR EN 2850 B1 & B2, ASTM D3039M-08 and ASTM D3410-03 (R08), ISO527 and ISO 14026 respectively. Using the graph in Figure 6, presented by Wilhelmsson [7] really show the large potential in utilizing Spread Tow fabrics, especially if the tapes are even thinner (today down to 20 micron) than the exemplified 70 micrometers one in Figure 5.

When designing a composite structure, materials property values must often be defined to minimize the probability of structural failure due to the inherent variance in the materials performance. Compliance is typically specified by selecting design values that ensure the probability of materials to resist

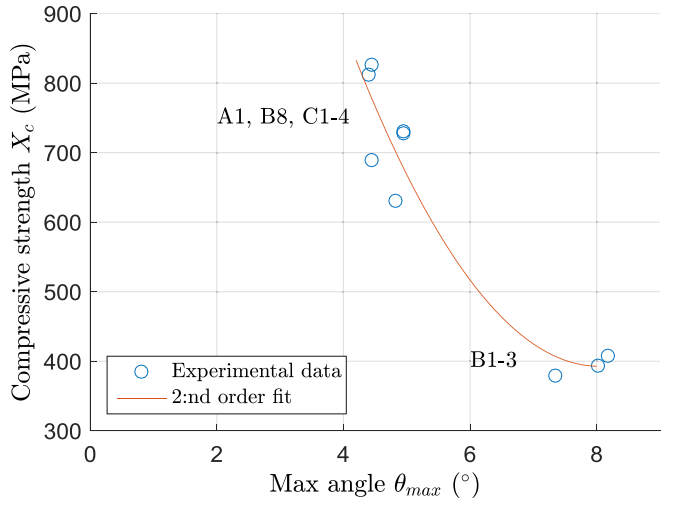

FIGURE 6

The compressive strength Xc as a function of the maximum angle θ max with a second order least square fit, from Wilhelmsson [7]

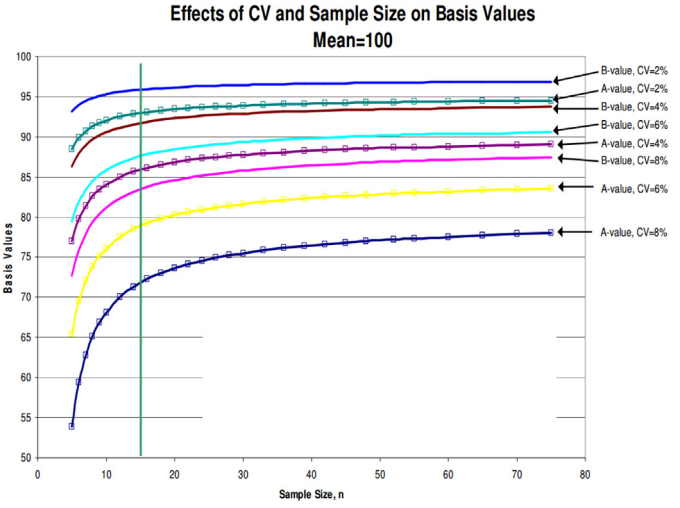

FIGURE 7

Effects of coefficient of variance (CV) and sample size on basis value, from [8].

failure. Usually probabilistic definitions such as A-basis and B-basis are used to frame the material variance. Figure 7 [8] provides the A and B coefficients of variance for a laminate depending on the specimen sample size:

- A-basis is used to identify where applied loads are eventually distributed through a single member within an assembly, the probability that a failure in the first would result in the loss of structural integrity of the component; 99 percent probability with 95 percent confidence interval.
- B-basis is similarly defined for the redundant structure, as the probability for which the failure of individual elements would result in the applied loads being safely distributed to other load carrying members; 90 percent probability with 95 percent confidence interval.

At a sample size of 15 or more, the CV value influence at a higher level on the basis design values than the number of samples.

NCF materials with its large variations will therefore be designed using lower values for statistical reasons. Continuous-length +/−45 Spread Tow fabric with its very uniform structure with virtually no uncontrolled in or out of plane waviness allowing mechanical data points with low CV. This theoretical approach will have to be further analyzed in bigger testing campaigns.

Conclusions

Continuous-length +/−45 Spread Tow fabrics have proven to be performance increasing for composite structures. These materials demonstrate economic benefits by reducing waste associated with the edge triangles when cutting bias patches from a 0/90 reinforcement fabric. The materials handling stability allows for the material to be subsequently processed, for example pre-pregged in a hot melt process. Finally, continuous-length +/−45 Spread Tow fabrics display a very controlled fiber undulation making them more predictable in its mechanical performance.

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FEATURE

A clearer vision of composite coatings

Nick Bailey

How one of the strongest, lightest automotive construction materials is overcoming the problems that have so far kept it from entering the mainstream.

Carbon fiber can trace its automotive origins back to 1981, when McLaren constructed a car with a carbon composite monocoque to win races in the Formula One World Championship. In 1992, the same British manufacturer rolled out the McLaren F1 road car – the first of its kind to operate a carbon structural framework. The innovate, lightweight composite was recognized to be lighter and more robust than conventional aluminum, which although recyclable was more likely to bend upon impact and put the safety of the driver at risk.

The pioneering F1 had set the scene for a carbon fiber revolution in the high-performance car industry; Mercedes followed six years later with the CLK-GTR, followed by efforts from Pagani with the Zonda and Ferrari with the Enzo. Synonymous with unparalleled capability, carbon fiber became a sought-after commodity for those wanting to replicate the performance of racing cars in their own models on the road. In a short space of time the supercar market got faster, lighter, and safer at a quicker rate than ever before. 25 years on from the McLaren F1, carbon fiber still retains the relevance and promise of its younger days. The brains at McLaren are continuing to drive the forefront of its development, most recently in December last year when they introduced the super-limited 675LT 'MSO Carbon Series', featuring 40 percent more carbon fiber than the conventional 675TL with just 25 models rolling out of the factory.

Carbon fiber is cool

As could be expected, with exclusivity to the high-end market came recognition of carbon fiber as a designer symbol. It was never thought of as desirable when McLaren rolled out that first Formula One chassis: rather, it was met with skepticism by the established teams. But its on-track success quickly changed that perception, and now the OEMS are embracing carbon in all aspects. Carbon fiber is no longer merely considered a functional organ element; it's become a fashion accessory. Like an exoskeleton, visual carbon fiber now envelops the external body in toughness and pedigree. OEMs want to show customers that they use this high-profile material. In other words: carbon fiber is cool.

Although its reputation stems from the performance car industry, carbon fiber is also finding its place in the everyday automotive market. In 2013, the BMW i3 became the first city car to feature a majority carbon fiber reinforced structure. Last year it sold 25,500 units worldwide, making it the sixth-most popular plug-in according to Hybrid Cars.

The upswing in demand for carbon fiber in the mainstream is countered by two fundamental drawbacks that are the production line. The first problem is cost. Currently, there is a hefty cost penalty to pay for a material that is lighter and stronger than the industry norm. Producing carbon fiber is an extremely labor intensive, artisanal activity, and despite their size even the largest OEMs don't boast the in-house workforce or resources to carry out this labor-intensive task.

The second issue is that carbon fiber cannot be coated conventionally. Its woven framework reads more like a fabric than a homogeneous component, and if treated using the familiar method of priming and painting, rough patches and blotches can appear on the surface where the carbon conducts irregular amounts of electrical charge. This makes it difficult to work into the body-in-white phase of manufacture, which in turn is perfectly suited to existing metals. Getting a smooth finish is critical if it is to become a regular fixture on everyday car panels, and at present the OEMs of the world have not developed their own effective solution to enable it to replace proven processes to coat metal and plastic-coated parts (Figure 4).

(Ad)dressing the issues

One company (Figure 1) that is helping OEMs to overcome these two challenges, and is in turning the tide to offer viable coatings for carbon fiber industry, is Project 12. Founded on the back of an established crash repair business, Project 12 has become a

0034-3617/ https://doi.org/10.1016/j.repl.2017.11.002

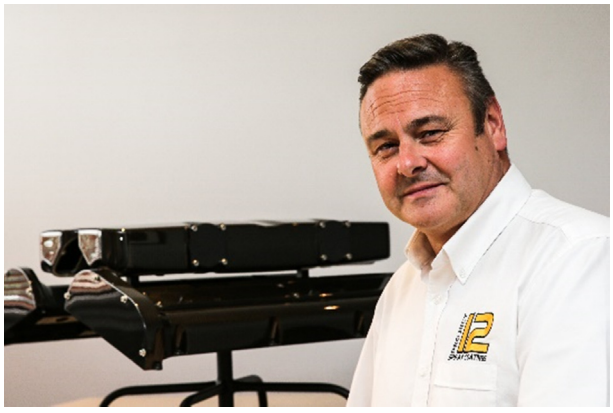

FIGURE 1
Dave King, managing director of Project 12 Coatings.

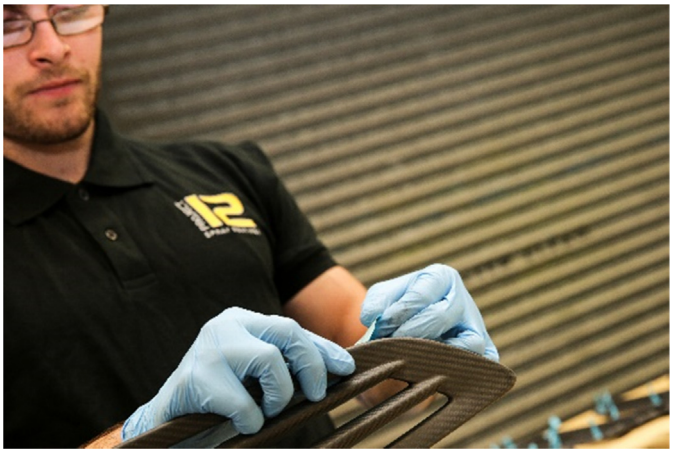

FIGURE 2
Carbon Fiber parts being masked prior to polishing.

FIGURE 3
Attention to detail is paramount to achieving exceptional finishes.

trusted leader in supplying car manufacturers with worked visual carbon fiber. Located in the heart of the industry-christened 'Motorsport Valley', the company produces customized finishes and coatings for carbon fiber elements primarily for the premium

FIGURE 4
Each part Project 12 completes is hand finished.

automotive market, and has already netted some high-profile OEM contracts (Figure 5).

The process of modifying carbon fiber components for visual appeal requires huge dedication (Figure 3), and its manual nature is something not suited to the production lines of the big OEMs. That's where companies such as Project 12 step in, as founder Dave King explains:

> "The process for creating parts is very labour intensive and very little is automated, most parts are hand-made. That means the surface structure varies significantly."
>
> "You need trusted and trained operators to do this work and at present, it remains too niche for most OEMs. That's why we have spent 10 years immersed in developing processes and procedures to achieve this," he says, "So much so that we have our own IP and have developed an accreditation with Loughborough University to recognise the skills needed. We have another programme starting with the National Composites Centre too."

The processes King describes extend beyond the training of its skilled staff. Project 12 has looked at every step of production. "Each stage of our process has been designed to minimise handling and damage," claims King (Figure 2). "We have cut process times down so we don't have stock on site too. We have tailored our entire flow to achieve this minimal work in progress, targeting no stock on site overnight".

Project 12's team of skilled technicians are trained to coat carbon fiber elements in a range of finishes. The baseline product is a glossy lacquer, although matte is becoming more popular. Each carbon fiber element arrives at the workshop in its standard form, pre-woven, before undergoing a treatment process that creates a smooth, vibrant finish that delights designers (Figure 7).

Harsh environments

Developments in coatings and their application means that coatings are suitable for more than just cosmetic elements in the cabin. "The materials technology and associated coatings have come so far that we are now coating composites that are used in high temperature environments such as airboxes, cam covers,

and intakes," claims King. "We also are involved in a project to coat carbon fiber wheels."

FIGURE 5

Polishing and hand finishing of parts all takes place in Banbury.

FIGURE 6

A range of colored finishes is now available for the automotive industry.

The ability to withstand harsh environments has seen demand for coated carbon fiber extend beyond automotive with Project 12 supplying coatings to the marine sector and beyond. "Automotive specifications are challenging but marine provides a new set of challenges in terms of aggressive environment," adds King.

Designers take the plunge

One market where surface appearance is crucial is in the design world. Project 12 has been involved in a number of projects with artists and designers including Alastair Gibson and is also currently working on a project to coat carbon fiber bath tubs for creative design agency SplinterWorks. The firm's stunning 'hammock baths' are created in composite carbon fiber and according to its designers, are the perfect expression of what can be achieved in composites. Unlike most bath tubs that feature flat bottoms and steep backs, Splinter Works' design is formed with a continuous curved surface that offers an unprecedented level of comfort. Designed for use in a wet room, the hammock bath is completely suspended from the walls, though a freestanding version is also available. Weighing just 14 kilos and spanning up to 3 m in length, the exclusive bath tubs, together with matching wash basin make a striking statement in traditional and modern environments.

> "Our customers have a very intimate relationship with the bath tub; they actually get very close to the product and its surface," says co-founder Miles Hartwell. "You are at eye level with the carbon and any imperfections in the weave or coating would be extremely discernible. We therefore require a smooth, peerless and beautiful finish." Of equal importance to the design team was longevity. "We also needed a surface finish that was going to last," adds Hartwell. "Whilst it may not be subject to damage from stone chips like car, it needs to stay looking beautiful for many years and that's why we have been rigorous on our selection of materials."

To date, Splinter Works (Figures 8 and 9) has produced over 50 so whilst exclusive, the allure of something that is not only beautiful but equally highly functional, means there is a demand for a

FIGURE 7

Project 12 has perfected application techniques for a range of composite materials.

FIGURE 8

Splinter Works hammock bath is a non automotive example of finishing from Project 12.

FIGURE 9
The Splinter Works Hammock Bath.

very special form of bath tub that retails at £19,800. "We've sold them around the world including China, USA as well as Europe," adds Hartwell.

A cure for color

Whilst other suppliers have tried to dye the weave to create colors in carbon fiber (Figure 6), Project 12 has focussed on creating all its colors and finishes from 'standard' carbon. According to King the benefits go beyond the color. "Our colours are all in the lacquer," says King. "That means that the composite manufacturer doesn't need to keep rolls of all the different coloured carbon in its fridge to offer different coloured parts. Composites materials have a shelf life so we can minimise complexity, storage issues and cost this way and offer a much wider range of colours without the hassle."

> "Designers have said that our approach creates a more vibrant finish with greater depth than the coloured fibres. One designer has cited that we can achieve an almost holographic appearance."

Companies such as Project 12 could be the answer to carbon fiber's two core problems mentioned above. Not only do its methods of production minimize costs on an extremely high value material; simplifying processes for OEMs but also undertaking manual tasks on high value parts that are susceptible to damage.

Carbon fiber has effectively become a fashionable accessory in the industry, and in doing so has picked up some of fashion's personality traits. Enveloped in an instant world, car customers want their products designed with the latest trends in mind, and delivered immediately.

With OEMs taking longer to get products to market (primarily thanks to their rigorous procedures and quality assurance) individual customizers and tuners have stolen a March with quick solutions for customers wanting something different.

Helping OEMs come up with one-offs or low volume solutions is another area that Project 12 is significantly involved in. "Our experience and supplier approvals means we can offer high quality and unique solutions," adds King. "We are very privileged to be invited to participate in thinktanks with designers and engineers to propose something new or based on a customer request, propose a design or finish."

Carbon crystal ball: what does the future hold?

Carbon fiber has the potential to be a game-changing material for the automotive industry, and its uptake by luxury manufacturers followed by more innovative brands BMW and Alfa Romeo demonstrates a ubiquitous demand for its properties. Project 12 and other similar companies have had a significant input to this rise, through the development of bespoke carbon parts for OEMs combined with a manufacturing process that solves issues of cost and resources for the big automakers.

But what direction should the carbon fiber industry take next? King has some idea of where much of the demand lies:

> "Expect to see more solutions beyond simple lacquering," says King. "Multilayers, the ability to include designs, logos or text within the composites. We can pretty much do any colour but you might have seen some of the clever use of colour variations within the lacquer at the Geneva Motor Show. I counted over a dozen cars with our products on display."

> "Other developments include incorporating diamonds in the lacquer to make it glisten and literally sparkle. We are doing some interesting things with gold now too. We had a lot of interest from the Far East for that concept. These are very exciting times as at one end, the technology becomes more mainstream and at the other end, it is evolving to be more exclusive. We are just at the beginning of a very exciting journey."

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Events Diary

4–6 December 2018
San Diego, CA, USA
Carbon Fiber 2018
Contact: CompositesWorld
Tel.: +1 858 552 1234
www.compositesworld.com

5–6 December 2018
Secunderabad, India
International Conference on Applied physics, Power and Material Science
Contact: Swami Vivekananda Institute of Technology (SVIT)
Tel.: +91 832 808 1815
E-mail: icappm2018@gmail.com
www.icappm.com

6 December 2018
Munich, Germany
Advanced Materials Engineering Conference 2018
Contact: MarketsandMarkets
Tel.: +9120 48598270
E-mail: events@marketsandmarkets.com
events.marketsandmarkets.com/advanced-materials-engineering-conference

11–13 December 2018
Shanghai, China
Carbontech 2018: The 3rd International Carbon Materials Conference & Exposition
Contact: DT New Materials
Tel.: +86 574 8722 7967
www.carbonconf.com/en

10–12 January 2019
Mumbai, India
ICERP 2019
Contact: FRP Institute
Tel.: +91 44 42900325
Fax: +91 44 22250349
E-mail: exhibition@icerpshow.com
icerpshow.com

30 January–1 February 2019
Tokyo, Japan
TCT Japan 2019
Contact: Secretariat of TCT Japan
Tel.: +81 3 5657 0760
Fax: +81 3-5657 0645
E-mail: tctjapan@jtbcom.co.jp
www.tctjapan.jp

19–20 February 2019
Charleston, SC, USA
SPE 2019 Thermoset Topical Conference – TOPCON
Contact: SPE
E-mail: shelane@gvineme.com
spethermosets.org

26–28 February 2019
Raleigh, NC, USA
Techtextil North America 2019
Contact: Sarah Hatcher
Tel.: +1 678 732 2403
Fax: +1 770 984 8023
E-mail: sarah.hatcher@usa.messefrankfurt.com
www.techtextil-north-america.us.messefrankfurt.com

6–8 March 2019
Rome, Italy
5th Annual World Congress of Smart Materials: 2019
Contact: Snowy Liang
Tel.: 86 411 84799609-814
Fax: 86 411 84795469
E-mail: snowy@wcsm-con.com
www.bitcongress.com/wcsm2019/

12–14 March 2019
Paris, France
JEC World
Contact: JEC
Tel.: +33 1 58 36 15 01
Fax: +33 1 58 36 15 15 15
E-mail: exhibitors@jeccomposites.com
www.jeccomposites-exhibitor.com

19–21 March 2019
Birmingham, UK
Aerospace Forum Birmingham 2019
Contact: advanced business events
Tel.: +33 01 41 86 41 60
Fax: +33 01 46 04 57 61
E-mail: lheemstra@advbe.com
www.birmingham.engine-meetings.com

24–28 March 2019
Nashville, TN, USA
NACE Corrosion 2019
Contact: NACE International
Tel.: +1281 228 6200
Fax: +1281 228 6300
nacecorrosion.org

28–30 March 2019
Parma, Italy
MECSPE
Contact: Senaf srl
Tel.: +39 023320391
Fax: +39 02332039610
www.mecspe.com/en

8–10 April 2019
Rosemont, IL, USA
North American Pultrusion Conference
Contact: ACMA
Tel.: +1 703 525 0511
Fax: + 1 703 525 0743
www.acmanet.org

9–11 April 2019
Detroit, MI, USA
SAE 2019 World Congress & Exhibition
Contact: SAE
Tel.: +1 724 776 4841
Fax: +1 724 776 0790
E-mail: customerservice@sae.org
www.sae.org

9–11 April 2019
Singapore, Singapore SEA-ASIA 2019
Contact: Seatrade Communications Singapore Pte Ltd
Tel.: +65 6294 2280
Fax: +65 6294 2780
E-mail: jkhoo@seatrade-asia.com
www.sea-asia.com

10–11 April 2019
Amsterdam, Netherlands
Composites in Construction
NetComposites Ltd
Tel.: +44, 01246 266 246
E-mail: info@netcomposites.com
compositesin.construction

15–17 April 2019
Dubai, UAE
World Nanotechnology Conference
Contact: Magnus Group
E-mail: worldnano@magnus-group.org
www.worldnanotechnologyconference.com

16–19 April 2019
Colorado Springs, CO, USA
35th Space Symposium
Contact: Space Foundation
Tel.: +1 719 576 8000
E-mail: Exhibitor@SpaceFoundation.org
www.spacesymposium.org

16–18 April 2019
Abu Dhabi, UAE
Global Space Congress 2019
Contact: Streamline Marketing
Tel.: +971 4 332 9029
Fax: +971 4 332 9648
E-mail: info@globalspacecongress.com
www.globalspacecongress.com

23–25 April 2019
Moscow, Russia
Composite-Expo 2019
Contact: Mir-Expo Exhibition Company
Tel.: +7 499 618 05 65
E-mail: info@mirexpo.ru
www.composite-expo.com

29 April–2 May 2019
Chicago, IL, USA
AUVSI XPONENTIAL 2019
Contact: The Association for Unmanned Vehicle Systems International
Tel.: +1 703 845 9671
Fax: +1 703 845 9679
www.xponential.org

20–23 May 2019
Charlotte, NC, USA
SAMPE 2019 Technical Conference and Exhibition
Contact: Anessa Sanchez-Olguin, SAMPE
Tel.: +1 626 521 9447
E-mail: Anessa@sampe.org
www.nasampe.org

21-23 May 2019
Detroit, MI, USA
Rapid + TCT 2019
Contact: RAPID + TCT
Tel.: + 313 425 3000
E-mail: exposales@sme.org
rapid3devent.com

11–13 June 2019
Shanghai, China
Aircraft Interiors Exhibition China 2019
Contact: Shanghai Golden Commercial Exhibition Co Ltd
Tel.: +86 21 5013 1760
Fax: +86 21 5013 1761
E-mail: info@goldenexpo.com.cn
www.aircraftinteriorsexpo.com.cn

19 Jun 2019
Binley, Warwickshire, UK
Ecocomp 2019
Contact: NetComposites Ltd
Tel.: +44 1246 266 246
E-mail: info@netcomposites.com
www.ecocomp-conference.com

3–5 September 2019
Bristol, UK
Adhesions 2019
Contact: The Institute of Materials, Minerals and Mining
Tel.: +44 20 7451 7300
www.iom3.org/society-adhesion-adhesives

3–5 September 2019
Birmingham, UK
Advanced Composites in Construction
Contact: NetComposites Ltd
Tel.: +44 (0) 1246 266 246
E-mail: info@netcomposites.com
acic-conference.com

10–13 September
Wichita, KS, USA
ICOLSE 2019: International Conference on Lightning and Static Electricity
Contact: Wichita State University
E-mail: icolse2019@gmail.com
www.icolse.com

10–13 September
Husum, Germany
HUSUM Wind 2019
Contact: BWE
E-mail: info@husumwind.de
Tel.: +49 4841 902-0
Fax: +49 4841 902-246
www.husumwind.com

23–26 September 2019
Anaheim, CA, USA
CAMX 2019
Contact: ACMA
Tel.: +1 703.525.0511
E-mail: info@thecamx.org
www.thecamx.org

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

20–22 November 2019
Mumbai, India
World of Composites at Techtextil India
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