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Natural fiber innovations:
BIOMATERIALS MAKE STRIDES IN COMPOSITES SUSTAINABILITY

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FEATURES

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» ON THE COVER

Materials have become a key focus when pursuing composites sustainability. One of the most obvious examples is the use of natural fiber reinforcement, increasingly used in automotive, from aesthetic interior components to safety-critical structures. A recent collaboration between Škoda Motorsport and Bcomp Ltd. has resulted in this novel electric SUV concept in which flax fibers are featured in the roof and roof vent (shown here), fenders, bumpers, sills, rear wing, co-driver footrest and leg rest, and more. See p. 28. Source | Bcomp Ltd. and Škoda Motorsport

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Reflecting on 2024 and looking ahead to 2025

» As we close out an eventful 2024, the *CW* editorial team is reflecting on a year filled with advancements and renewed focus within the composites industry, whether that was the growing use of thermoplastics in aerospace, continued ramp-up of AAM, composites recycling innovations and implementation of sustainable practices across supply chains, and ongoing hydrogen storage development.

JEC World 2024 in Paris, an international platform for connecting the industry, was brimming with enthusiasm surrounding the Summer Olympics. A sense of community and collaboration was palpable on the show floor. The trade show emphasized the multifaceted role composites play in keeping us connected, from the transportation we take, to how we communicate day to day, and even the sports and recreational activities we play and enjoy.

The sustainability theme loomed large at multiple industry events this year. CAMX 2024, for example, reminded us that while composites have long been synonymous with lightweighting and energy efficiency, today's focus also includes responsible material sourcing, recycling and waste reduction — things that are quickly becoming essential strategies embedded within all manufacturing operations.

On a similar note, *CW* hosted an online Tech Days event in April covering the trends in composites sustainability, emphasizing how OEMs now expect comprehensive environmental responsibility from their supply chains. Speakers also explored practical pathways for the industry to achieve decarbonization goals, including bio-based materials and energy-saving processes. It's clear that sustainability is a new, permanent part of industry conversation.

Many of these discussions continued at this year's Carbon Fiber, which represented the growing use of carbon fiber in a range of sectors including wind energy and hydrogen, and provided insights into what may be in store regarding composites use in aerospace. The conference also offered a healthy discussion of global factors influencing carbon fiber supply and demand, with a particular focus on the ramifications of a surplus of carbon fiber from China entering various markets.

Another exciting industry trend is the continued growth of composite materials use in space applications. In November, a second *CW* Tech Days event on this topic explored the journey of composites from their foundational role in early space exploration to their current applications in private space missions. The use of composites in payload fairings, satellite structures and thermal protection systems, just to name a few examples, has paved the way for groundbreaking partnerships between commercial space companies, NASA and the ESA, illustrating how innovation continues to push boundaries.

As we move into 2025, *CW* is looking forward to even more exciting opportunities for the composites community. In March, JEC World 2025 will be celebrating its 60th anniversary under the theme "Pushing the Limits," showcasing the limitless potential of composite materials. In this issue, we bring you an exclusive interview with Eric Pierrejean, CEO of JEC Group, where he shares insights on industry milestones and the importance of fostering connections and innovations (p. 34).

Looking even further ahead, *CW* plans to host more of its own industry events. An April 2025 *CW* Tech Days will explore the intricate processes of bonding and welding composites, while a November installment will shine a light on the contributions of composites to electric vehicle advancements. Next year's Carbon Fiber will take place in Wichita, Kansas, where we'll partner with the National Institute for Aviation Research (NIAR) at Wichita State University to bring you insightful presentations, tours and demonstrations.

As we gear up for another dynamic year, *CW* remains committed to bringing you the news, technological developments and educational offerings that help inform industry and keep us connected. In the new year we plan to further expand our editorial coverage with international perspectives, in-depth company profiles and insights into the intersection of composites with the broader manufacturing sector.

The new year holds the promise of new challenges and greater opportunities, and we can't wait to share it all with you. Here's to an exciting year ahead! CW

Use of *CW* content in AI

The world of media is rapidly changing with the influence of social media and AI-generated content. For *CW*, maintaining ethical and legal standards is more important than ever. As a leading source for composites industry news and information, *CW* works hard to develop and share that content, and it should not be used in any AI platform. However, *CW* welcomes the opportunity to partner with anyone working to forward the industry. We advise that anyone interested in using or reusing *CW* content — including, articles, text, images and media clips — reach out to us in advance to secure proper permissions and protect against copyright infringement.

The evolution, transformation of DEA from lab measurements to industrial optimization

By **Alexander Chaloupka** / Founder, sensXPERT

» In the fast-paced industrial environment of today's plastics and composites manufacturing, ensuring product quality and optimizing processes are essential. Manufacturers face unique challenges, such as precisely controlling material properties and immediately responding to process variations. However, this becomes even more complex as consumers demand increased recycled and/or bio-based content, creating a cascade of uncertainties in materials and processes. Advanced measurement techniques are crucial to maintaining reliable, high-performance products and operational efficiency for a competitive advantage.

One such advanced measurement technique is dielectric analysis (DEA), which measures the dielectric properties of materials (e.g., permittivity and conductivity) as they cure or undergo phase transitions. These dielectric properties provide valuable insights into the molecular dynamics and structure of the materials, enabling characterization and optimization of plastics and composites molding and curing processes.

Traditional DEA techniques are primarily confined to laboratory settings, where they offer high precision and reliability. These lab-based DEA measurements are often conducted using dielectric spectroscopy, a technique for measuring the dielectric properties of a material as a function of frequency. Spectroscopy is typically performed using network analyzers, which measure impedance and dielectric properties to evaluate electrical response and stability, or LCR meters, which measure inductance, capacitance and resistance.

Netzsch DEA 288 Ionic, a lab-based dielectric measurement system.
Source (All Images) | sensXPERT

Fundamentals of DEA

The fundamental principle of DEA involves applying an alternating voltage to a material and measuring its response in terms of the resulting current and phase shift between the voltage and current. In short, it penetrates the material with an electric voltage and measures the time it needs to respond. This response is influenced by the material's molecular structure and dynamics, providing insight into its behavior and properties. Key concepts include:

- **Permittivity (ε):** This measures how much electric field the material can store. It provides insight into the material's ability to be polarized by an electric field, which is crucial for understanding molecular interactions and structural changes.
- **Conductivity (σ):** This measures the material's ability to conduct electric current. It is directly related to the mobility of charge carriers within the material, indicating the progress of curing or other chemical processes.
- **Phase transitions and curing processes:** DEA is particularly valuable for the in-process monitoring of phase transitions (e.g., from liquid to solid) and curing behavior in polymers and composites. It can track the entire process in real time, offering precise control over manufacturing conditions.

Evolution of analyzing material behavior

DEA was first developed in the 1980s at the Massachusetts Institute of Technology (MIT) in the U.S., driven by the pioneering work of David D. Day. His effort laid the groundwork for understanding and using dielectric properties to analyze material behavior.

In the decades following its development, DEA became a widely adopted tool for analyzing material properties in controlled lab settings. Early DEA applications focused on providing highly accurate data for understanding the molecular dynamics of materials, particularly polymers and composites. As the technology matured, several companies began exploring its broader application in manufacturing environments.

By the 2000s, companies like Lambient Technologies (Cambridge, Mass., U.S.) began developing sensors that primarily used alternating current (AC) to monitor a wide variety of curing polymers, including epoxies, polyurethanes and fiber-reinforced composites. These sensors provided key insights into reaction rates, viscosity and cure states, which helped optimize manufacturing processes like autoclave curing and pultrusion.

Around the same time, Synthesites (Uccle, Belgium), founded in 2008, introduced direct current (DC) sensors tailored for specific industrial applications such as real-time resin curing in composites production, particularly in aerospace and wind energy sectors. Synthesites' DC sensors allow for precise monitoring of resin curing, enabling detailed measurements of conductivity and resistivity during the transition from liquid to solid.

While companies like Lambient and Synthesites have continued to advance DEA for specific applications, the ability to fully integrate DEA into diverse and dynamic manufacturing environments has still posed significant challenges. However, the technology has continued to evolve further, including the ability to handle the variability and real-time demands of industrial production lines.

Netzsch: Transition from lab to manufacturing

Building on the foundation of MIT's work, Netzsch (Selb, Germany), a global company developing precision measurement technology, acquired Micromet Instruments and began developing DEA technology further, pushing DEA into more complex manufacturing environments.

SensXPERT's industrial dielectric system with a production machine.

One of the key challenges in applying DEA to industrial environments, particularly for advanced materials like carbon fiber-reinforced polymers (CFRP), is the material's electrical conductivity, which often causes short circuits in dielectric sensors.

To address this, Netzsch developed coated sensors, which achieve accurate dielectric measurements even in electrically conductive materials. These sensors overcame a significant barrier, enabling manufacturers to gather real-time data on material behavior during processing, even in demanding environments like CFRP component production. This innovation, coupled with Netzsch's long-standing expertise in material science, laid the groundwork for taking DEA beyond static lab measurements into dynamic, real-world applications.

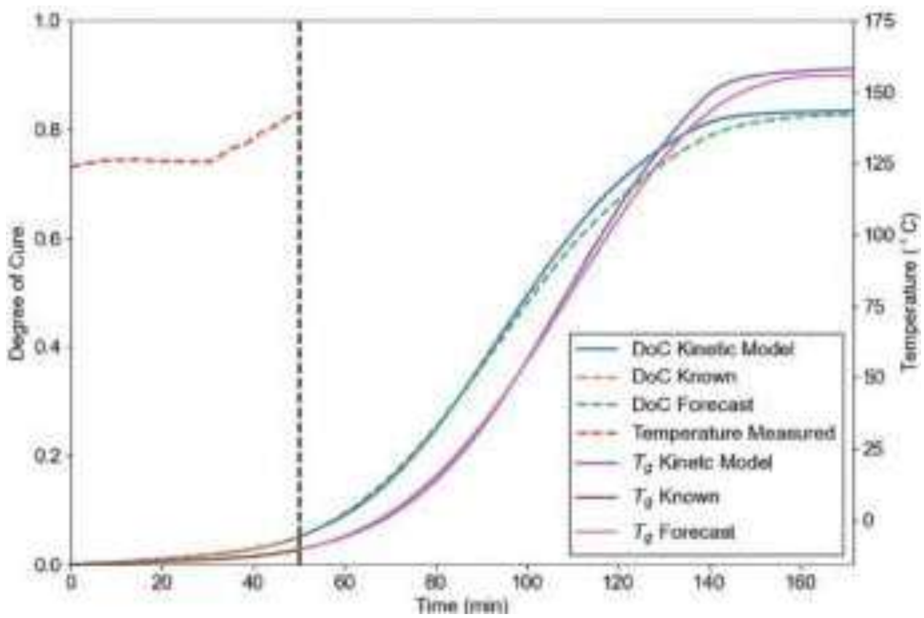
In addition, it paved the way for the creation of the sensXPERT concept in 2019, which aimed to advance DEA from a measurement technology to an integrated solution that improves efficiency and quality control in series manufacturing processes. The concept received funding from Netzsch shareholders in 2020. The first product created was capable of real-time communication with manufacturing machines and integrating material kinetics with in-mold material behavior through machine learning models. In 2021, Netzsch Process Intelligence GmbH was founded to commercialize the sensXPERT technology.

Transforming DEA into an industrial tool

A pivotal moment in the evolution of sensXPERT was the recognition that traditional methods for analyzing DEA data were labor-intensive, limited and lacked standardization. With no existing software capable of correlating DEA data to actionable insights like the degree of cure (DoC) or crystallization, sensXPERT responded by building a dedicated data science team to tackle these challenges.

This led to the creation of a robust tech stack equipped with sophisticated algorithms and visualization tools. These tools not only process DEA data in real time but also correlate it with lab results to deliver accurate, actionable insights into material behavior during production. The integration of machine learning models has transformed the system's capability, enabling it to predict material property changes and dynamically adjust manufacturing parameters, significantly improving process efficiency and product quality.

Another crucial step was the incorporation of cloud computing and advanced software solutions, which facilitates seamless communication between DEA equipment and production systems on the shop floor. This digital infrastructure enables sensXPERT to operate as a software- and data-driven platform. While hardware remains critical for capturing material data, the entire ecosystem is powered by data science, edge computing, cloud connectivity and secure cloud »



Shown here is an example of sensXPERT's DEA technology predicting degree of cure (DoC). As the part is being processed, the prediction becomes more precise, and with it, the cycle can be dynamically adjusted to end at the point at which the processor's desired DoC is reached.

operations. For Netzsch, this shift from a hardware-centric to a software-driven approach marks a transformation in the manufacturing industry, moving away from static lab testing toward real-time data processing and predictive analytics.

Through these innovations, sensXPERT aims to gives manufacturers the ability to monitor, predict and dynamically optimize processes — providing deeper control over production quality and efficiency.

Future trends in DEA technology

Several trends are set to shape the future of DEA as industries seek more precise, efficient and sustainable manufacturing processes. These trends are driven by the growing need for advanced materials, sustainability initiatives and real-time process optimization across various manufacturing sectors.

One of the most significant advancements is the *implementation of high-frequency analysis*. High-frequency DEA can provide new levels of insight into material compositions and molecular dynamics. Beyond just monitoring phase transitions, high-frequency data allows manufacturers to better understand complex materials and identify opportunities for further optimization.

Another key trend is the *continuous integration of AI and machine learning* into DEA systems. By combining real-time sensor data with predictive models, AI-driven systems can offer dynamic process adjustments autonomously that ensure optimal curing, material properties and cycle times. Machine learning will enable these systems to "learn" from previous production cycles, improving accuracy and efficiency over time.

Moreover, the push for sustainability is leading to advancements in DEA technology that *support the use of recycled and bio-based materials*. With increasing environmental regulations and the growing demand for eco-friendly products, DEA systems will play a crucial role in ensuring that these materials — which often exhibit greater behavioral deviations during processing — meet performance standards while maintaining process efficiency. The newly founded Avidens consortium is one example of how industry leaders are coming together to leverage technologies like DEA to enhance the processing of recycled materials.

The rise of *digital twins* is another trend closely tied to the future of DEA. A digital twin is a virtual model of a physical system or process, and DEA data can be integrated into these models to simulate material behavior during manufacturing. This enables manufacturers to optimize processes virtually before implementing changes in the physical world, reducing trial and error, and leading to more efficient operations.

Lastly, the *integration of cloud computing and Internet of Things (IoT)* will further enhance the accessibility and scalability of DEA systems. By connecting DEA sensors and systems to cloud platforms, manufacturers will have real-time access to production data from anywhere, allowing for more seamless remote monitoring, analysis and decision-making. This trend will also foster collaboration between different parts of the supply chain, as stakeholders can share data and insights more easily.

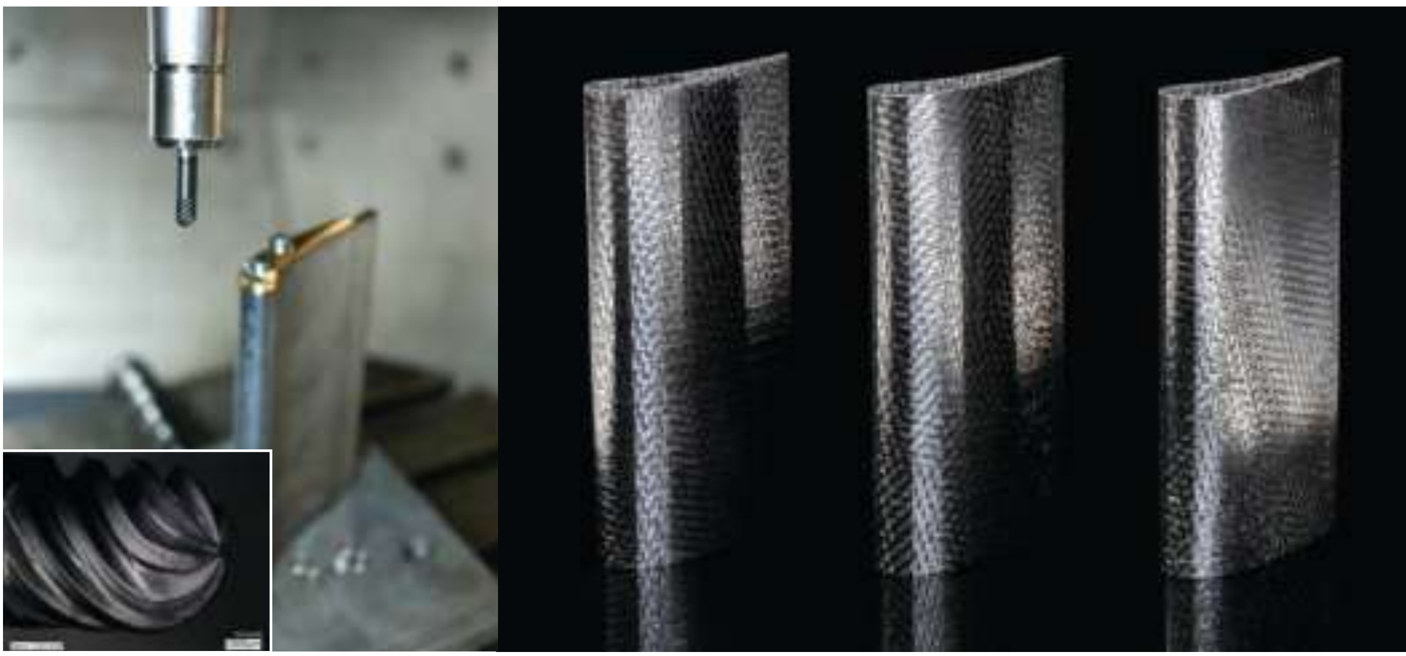
As these trends continue to unfold, DEA will become a more critical tool across a variety of industries, including automotive, aerospace, electronics and renewable energy. The combination of high-frequency analysis, AI integration, sustainability efforts and digital infrastructure will transform DEA into a more powerful and versatile technology that addresses the growing complexities of modern manufacturing. CW

ABOUT THE AUTHOR

Dr. Alexander Chaloupka is a polymer expert at heart. After studying physics, he began his career in the Department of Thermophysical and Chemical Analysis and Rheology at the Fraunhofer Institute for Chemical Technology (Augsburg, Germany). He subsequently continued his professional journey at Netzsch Analyzing & Testing (Selb, Germany). With more than 10 years of experience in R&D, sales and general management, Chaloupka founded sensXPERT, the first Netzsch Group corporate venture, in 2021. **www.linkedin.com/in/alexanderchaloupka/**

Developing milling for CMC because grinding takes too long

By Joshua Macken / Development Engineer, Hufschmied



Traditionally, turbine blades in aircraft engines have been metal (left). Now, ceramic matrix composite (CMC) versions are being explored (right) enabling higher temperatures and lower weight for more efficient engines. A cutting tool developed by Hufschmied (bottom left) offers an optimized micro-geometry specialized for CMC machining needs. Source | Hufschmied Zerspanungssysteme (left) and DLR (CC BY-NC-ND 3.0) (right)

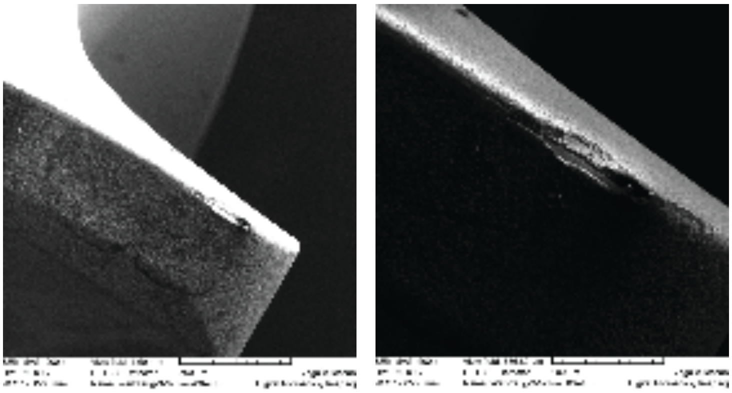
» Extreme heat and strong temperature fluctuations pose major challenges for materials in aircraft engines. In order to increase the efficiency and effectiveness of engines, the trend is toward ever-higher operating temperatures. Ceramic materials in particular, which have excellent high-temperature properties, offer the potential for improved temperature resistance. Monolithic ceramics, though, are brittle, and thus not suitable as structural components. However, by adding fiber reinforcement to a ceramic matrix — i.e., ceramic matrix composites (CMC) — damage-tolerant properties are possible. Silicon carbide (SiC/SiC) CMC developed at the German Aerospace Center (DLR, Augsburg) can currently withstand uncooled continuous loads of up to 1250°C, with potential for even higher temperatures. In addition, the lower density of these materials offers the possibility to further reduce aircraft engine weight and thus increase thrust-to-weight ratio for improved efficiency, necessary for aviation's decarbonization.

One goal has been to use CMC to replace metal turbine blades in aircraft engines. But this has been repeatedly postponed for several reasons, including the lack of efficient production processes and machining/postprocessing of the CMC blanks required for tight-tolerance blades. DLR and Hufschmied Zerspanungssysteme GmbH (Bobingen, Germany), with its U.S. subsidiary Hufschmied Tools Corp. (HZS), collaborated with the Augsburg University of Applied Sciences (Augsburg, Germany) in the SCANCUT project to develop new manufacturing technologies for CMC turbine components.

Hufschmied is known in the industry for process optimization of carbon- and glass fiber-reinforced polymer (CFRP and GFRP) composites machining and already has experience working with machining SiC/SiC. In 2018, together with a manufacturer of CMC materials, it succeeded in replacing a grinding process with milling for SiC/SiC bearing sleeves that reduced the overall machining time by around 70%. As a partner in the DLR-funded SCANCUT project, Hufschmied has taken another step forward.

CMC properties demand a new approach

The desired properties of CMC are also those that make machining and postprocessing so difficult. Fiber-reinforced ceramics have high temperature resistance and high rigidity combined with high toughness, while the SiC fibers give the material a quasi-ductile behavior. Near-net-shape components also require postprocessing in order to produce smooth surfaces and achieve the tightest possible tolerances. Thus, CMC has mostly been machined by grinding instead of cutting because the extremely high hardness and heat resistance of SiC lead to a very high load on the cutting edge of milling tools.



The problem with conventional diamond-coated solid carbide tools is that chipping occurs when machining CMC. Source | Hufschmied Zerspanungssysteme

Traditionally, such situations would be addressed by using diamond-coated tools. With CMC, this was previously not possible because the diamond coating would flake off after a short time. In the 2018 project, Hufschmied therefore developed a polycrystalline diamond (PCD) milling tool specifically for the SiC/SiC bearing sleeves. But is this the only option?

PCD tools are expensive and complex to manufacture. Thus, this material is more commonly used for cutting inserts. At Hufschmied, the geometries of the cutting edges have always been one of the factors used to achieve the greatest improvements in machining. However, PCD offers limited possibilities for this. So, a new approach was needed.

Test series with dummy material

Work in the SCANCUT project was performed using a more commonly available and less expensive CMC made with carbon fiber reinforcement in a carbon/SiC matrix known as C/C-SiC. In addition to making the test series affordable, it was found that the behavior of C/C-SiC hardly differs from that of SiC/SiC. Thus, testing began at the Hufschmied Technology Center in Bobingen, south of Augsburg, with the aim to find an alternative to PCD in order to produce complex surfaces on CMC blanks more cost-effectively. Compared to PCD tools, diamond-coated solid carbide tools allow greater freedom of geometry at reduced costs. That is, provided that a way can be found to avoid the potential for uncontrolled wear of coated tools.

Trial, error and breakthrough

Although a new standard tool for machining CMC is not yet available to buy, development has reached a stage where it is clear that efficient machining with diamond-coated solid carbide tools is possible. To continue to push this technology forward, Hufschmied carried out a series of tests with four different tool variants. Three aspects were varied, and their interactions examined: cutting edge geometry, coating technology and cutting parameters.

When it came to the tool cutting edge geometry, the initial focus was only on the micro-geometry of the cutting edge. Issues such as the number of cutting edges or the macro-geometry were left out for the time being and will be explored in planned follow-up projects. The second aspect investigated was the coating. Hufschmied has developed numerous solutions for particularly abrasive materials (such as CFRP, GFRP and graphite) and has already patented its own microcrystalline diamond coating. Thus, it experimented with variants of this technology in order to test whether a durable coating can be developed for CMC. The third aspect — and this is essential for any machining optimization — was the variation of the cutting parameters. Experiments were carried out with infeeds between 0.05-1 millimeter, feed per tooth between 0.01-0.2 millimeter and spindle speeds between 1,000-20,000 rpm.

With a newly developed micro-geometry and a diamond coating optimized for CMC, it was then possible to develop a cutting tool prototype that showed controlled wear behavior. This means that the coating wears gradually but does not chip off when confronted with the fiber-reinforced ceramic, as is the case with conventional diamond-coated tools.

"Based on this initial success, we will continue to develop and test until we have made our contribution to the triumphant advance of CMC in the aerospace industry and beyond," explains Christel Hufschmied, managing director of Hufschmied Machining Systems. "We've made a start and now it's time to compare the tool life of the new tools with that of PCD tools. The closer those are, the more economically interesting our new approach will be." CW

ABOUT THE AUTHOR

Joshua Macken has been a development engineer at Hufschmied Zerspanungssysteme GmbH (Bobingen, Germany) since September 2023. In 2019, he graduated from Munich University of Applied Sciences in applied research in engineering sciences (M. Sc.), and for 3 years was a research assistant at the THA, studying the machining of CMC materials. In his current role at Hufschmied, Macken's main topics of interest include machining ceramic and CMC materials, process monitoring and digitalization.

Composites business growth through diversification, innovation

By Scott Francis / Editor-in-Chief

RWC's Salt Lake City facility houses multiple filament winding machines, including advanced multi-spindle and large-diameter winders. Source (All Images) | Rock West Composites (RWC)

Rock West Composites (RWC), a provider of advanced composites solutions headquartered in San Diego, California, has carved out a unique position in the industry through its commitment to diversification, continuous improvement and what it says is "a relentless focus on world-class standards." RWC specializes in the design, engineering and production of composite materials and structures, and serves a variety of industries, including aerospace and defense (radomes, unmanned systems and other structures), space, aircraft and commercial.

Founded in 2007 by executive vice president Keith Loss and CEO Jim Gormican, RWC has experienced remarkable growth, achieving a compound annual growth rate (CAGR) of more than 20% over the past decade. Gormican attributes the company's success to a strategic approach that prioritizes stability and long-term sustainability over chasing the next big contract.

Both Loss and Gormican are industry veterans with decades of experience in composites work in the aerospace and defense sectors, including applications such as communications satellites and radomes.

RWC technicians perform prepreg ply placement using a laser projected template.

"We'd both already had full careers. Before RWC, I'd sold another company, Composite Optics, to Alliant Techsystems in 2003, and I stayed with them for 5 years as CEO," Gormican says. "Then in 2007 we started Rock West. My wife says I flunked retirement, but I love building things, and building a company is the coolest thing you can build."

RWC's diversified portfolio spans four key market segments: space (~35%), aircraft (~25%), defense (~20%) and what Gormican calls commercial — comprising industrial, oil and gas, sporting goods and e-commerce (~20%). This balanced approach has helped the company weather industry fluctuations and maintain a steady growth trajectory, even during challenging times.

"We've always been focused on building a world-class company, not just maximizing short-term profits," Gormican says. "That means diversifying our business, investing in our people, and constantly striving to improve our processes and capabilities."

Capabilities

RWC produces parts using a wide range of composite materials, including carbon fiber, glass fiber and Kevlar. The company offers multiple manufacturing processes such as filament winding, resin infusion, compression molding and prepreg layup. RWC also provides engineering and technical support for product development. This includes design optimization, material selection and prototyping services.

In recent years, RWC has significantly expanded its manufacturing capabilities across multiple locations that comprise 300,000 square feet in total. With locations in Salt Lake City, Utah; San Diego, California; and Tijuana, Baja California, Mexico, each facility contributes unique capabilities to support RWC's mission of delivering advanced composite solutions.

In 2021, RWC established a 107,000-square-foot San Diego facility that serves as the company's headquarters and houses corporate offices, engineering and product development, as well as manufacturing operations. With 80,000 square feet dedicated to manufacturing, the site has room to regularly explore expanding capabilities as demand grows.

The facility specializes in prototyping and the production of large and complex composite parts (masters, molds and composite hardware) with high precision. Leveraging state-of-the-art equipment for drilling, trimming and contouring, it is equipped with multiple CNC machines. Other supporting equipment includes a laser ply placement projector, precision inspection CMM equipment such as a Romer articulated arm and Leica laser tracker from Hexagon (North Kingstown, R.I., U.S.), testing equipment, environmental chambers, a large spray booth and grinding stations.

San Diego's second location, only a few minutes from RWC's headquarters, is home to its aircraft division, doing business as Performance Plastics. This Nadcap-certified facility adds metallic manufacturing, machining, forming and bonding to RWC's technical expertise. It has multiple autoclaves and equipment to support the components it produces for military and commercial aircraft.

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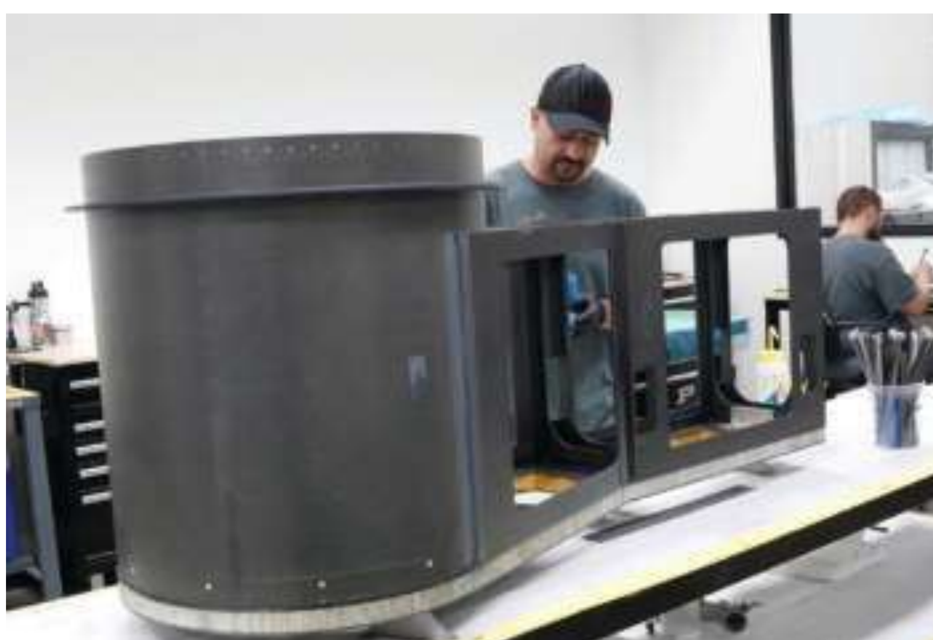

RWC technicians perform precision assembly for a large aperture telescope structure delivered to EOI Space.

RWC supplied multiple configurations of machined and tested composite struts with bonded fittings for the *Odysseus* lunar lander. Source | Intuitive Machines

Meanwhile, RWC's Salt Lake City facility, focused on its e-commerce operations, houses multiple filament winding machines, including advanced multi-spindle and large-diameter winders. These machines can produce tubes up to 315 inches long and 30 inches in diameter, enabling RWC to serve industries requiring both small and large composite tubes. The site also features custom resin mixing and dispensing systems, which ensure precise resin ratios for consistent quality. Equipment for roll wrapping tubes and infusing plates, as well as a large machining center and precision inspection and testing equipment are also present at this location.

RWC's facility in Tijuana, Baja California, Mexico focuses on diverse composites manufacturing techniques, including resin infusion, bladder molding, roll wrapping, wet layup and precision assembly. This location includes a climate-controlled area for processes requiring strict environmental control, ensuring quality for sensitive applications. Located just 30 minutes from RWC's San Diego headquarters, it supports the company's North American operations with production flexibility and cost efficiencies. Altogether, these capabilities enable RWC to serve a broad range of industries with advanced composites, including customized solutions and scalable manufacturing options.

One aspect of RWC's diverse approach is its e-commerce business. RWC has evolved from selling its own products to offering a full composites marketplace with products made by dozens of high-quality composites manufacturers. The company carries tubes, rods, plates, materials, connectors, resins, kits and more, in addition to offering fabrics and prepreg with no minimum order available by the linear yard.

"We think we have great capability to do what we need to do to help our customers be more competitive," says Gormican. "We keep spending capital every year to keep supporting that. If there's something that we don't have, we tend to go get it — assuming the business case makes sense."

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ABOVE: RWC technicians perform radio frequency (RF) testing on an advanced radome for defense applications.

LEFT: RWC specializes in deployable space structures such as this reflector dish.

The new space race

As RWC looks to the future, Gormican sees significant opportunities for continued growth, particularly in the rapidly evolving space sector. RWC's expertise in engineering, production and advanced materials has made it a trusted supplier for a wide range of spacecraft components, from launch vehicle structures to deployable booms and solar arrays, and thus a trusted partner for established players and a new wave of private space companies alike.

"The new space industry is a perfect fit for our capabilities," Gormican says. "We've got the technical chops to handle complex, high-precision parts, and we also have the production mindset to deliver those parts at scale and at a competitive cost. That's a sweet spot that a lot of our customers are looking for."

He adds: "The new space industry is really just getting started, and we're positioned to be a key player in that transformation. By applying our expertise in high-tech, production-oriented solutions, we can help our customers drive down costs and scale up their operations."

Continuous improvement

RWC's ability to rapidly adapt to changing requirements and deliver high-quality, cost-effective solutions has made it a valued partner for major aircraft OEMs and defense contractors. The company's business in these sectors has seen significant growth, driven by increasing demand and a growing backlog of orders.

Gormican says that RWC's success is driven by a relentless focus on continuous improvement. The company actively benchmarks its performance against industry leaders, using tools like the Top Shops benchmarking survey to identify areas for growth and optimization. This commitment to excellence is reflected in RWC's culture, which emphasizes employee ownership, transparency and a collaborative, in-person work environment. The company's low employee turnover rate, which Gormican says is well below industry averages, is a testament to its ability to attract and retain top talent.

"Not only are we excited we are on the Top Shops list, but we've also earned a space on the Top Workplaces list for the past several years in both San Diego and Salt Lake City," Gormican adds. "We're constantly challenging ourselves, learning from others and finding ways to raise the bar in everything we do — from our manufacturing processes to our employee training and development. We're not trying to be the biggest — we want to be the best." CW

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Proving thermoplastic composites match carbon fiber/epoxy performance in road bikes

By Ginger Gardiner / Senior Technical Editor

CDCQ, LxSim, Addcomp and Argon 18 collaborated to optimize a carbon fiber/PA6 bike seat post, democratizing AFP, and demonstrating materials and process for future designs and production.

Source (All Images) | CDCQ, LxSim, Argon 18

» Thermoplastic composites (TPC) are at the forefront of the revolution in materials and processes for the cycling industry, says Vincent Lemay, VP of R&D for Argon 18, a high-quality bike manufacturer in Montreal, Canada. "I think the industry will go this way in the near future because these materials enable quick, efficient and less labor-intensive processes [see Learn More for *CW*'s 2022 feature on bike frames]. But in the cycling industry, we have very detailed, tailored layups, which is why they are done manually right now."

These layups are also almost exclusively *thermoset* composites, notes Lemay, using carbon fiber-reinforced polymer (CFRP) based on epoxy prepreg for road racing models, where lightweight performance is paramount. "This is what we wanted to address," he explains. "How can we develop comparable carbon fiber [CF] layups with thermoplastics yet retain the high performance of traditional epoxy-based CFRP?"

To answer this, Argon 18 worked with the Quebec Composites Development Centre (CDCQ, Saint-Jerome, Canada) and engineering simulation specialist LxSim (Bromont, Canada), as well as composites automation company Addcomp (Sherbrooke, Canada) to evaluate six different TPC materials. It developed an optimized layup for 2D blanks, which were made using automated fiber placement (AFP), shaped onto a mandrel and then compression molded using a bladder-based process to produce and test two of these materials in a bike seat post demonstrator.

Project partners and objectives

The project began with Addcomp's installation of a customized robotic AFP cell at CDCQ. "We were looking at different projects to demonstrate what this cell could do," explains Yoann Bonnefon, CEO of Addcomp. "We were already working with CDCQ to evaluate different TPC materials and also wanted to collaborate with LxSim due to their expertise in composites optimization."

Argon 18 was also interested in testing various TPC materials. "CDCQ is a longstanding partner helping us explore how to produce more efficient, lighter and safer bicycles," says Lemay. His team suggested the bike seat post as a basis for comparison. The project began with material characterization and selection, followed by fabrication and testing of the demonstrators.

"We started in 2023, and performed the materials testing in our lab," says Yves Mathieu, project manager at CDCQ. "Our initial tests were on flat coupons made using robotic AFP layup with different angles and then hot press molded into plaques." The team tested six different unidirectional (UD) tape materials made using standard modulus CF with various thermoplastic polymers — Rilsan polyamide11 (PA11), polypropylene (PP), Maezio and Gordon Plastics polycarbonate (PC), Toray TC910 with polyamide 6 (PA6) and PA12 tape from Suprem — and compared their properties to the baseline CF/epoxy material, selecting two TPC materials to use for the demonstrator parts.

LxSim used the initial property data for those two TPC materials in its finite element analysis (FEA) design and optimization of the demonstrator, aiming for parity with baseline CF/epoxy parts. "We then used the robot cell to lay up optimized 2D blanks and used a bladder molding process to convert those into hollow bike seat posts," says Mathieu. "These demonstrators were then tested by Argon 18."

"We chose a seat post because it's a simple shape," explains Lemay. "But because it attaches the saddle [seat] to the bike frame, it has quite a complex load case that we can simulate. Our initial goal as a bike manufacturer was to characterize and compare the TPC materials and then use that data to feed our FEA simulations to compare with existing CF/epoxy parts. But we also wanted to optimize the layup for the seat post and develop the manufacturing process at the same time. These are the biggest roadblocks for us to start using TPC: how to optimize and produce the parts efficiently. If we can simulate the failure mode accurately, we can then optimize our part using FEA, and from there the layup for larger and more complex parts."

Materials testing, process development

"We programmed the robot to apply the PA6 and PC composite tapes," says Mathieu, "which was a bit tricky because they were not the same areal weight as the CF/epoxy that we were used to. So, we needed to tweak it to achieve the prescribed layups. The fiber areal weight of the TPC tapes was defined by the material supplier, and though we targeted 150 gsm, some materials were 131 gsm."

"Our main selection parameters were stiffness and low density," adds Mathieu. "But there are limitations from the heating system in the AFP process — for example, our system uses hot air. So, we also compared materials in terms of processability and price to make our selection."

The AFP layups were then placed into two-part aluminum molds and consolidated in a Carver (Wabash, Ind., U.S.) 100-ton heated press. Molding time was 5 minutes once melt temperature was reached. Test coupons were waterjet cut from various plates made to fully characterize the two selected materials per ASTM specifications for flexural, tensile, compressive and in-plane shear properties.

The two UD tape materials Argon 18 chose to make the bike post demonstrators were a CF/PA6 from Toray Advanced Composites (Morgan Hill, Calif., U.S.) and a CF/PC from then Gordon Plastics (Englewood, Col., U.S.), acquired by Toray in November 2024. Lemay notes that low-melt polyaryletherketone (LMPAEK) polymer (Victrex, Lancashire, U.K.) and other high-performance TPC materials used in aircraft were not considered due to cost. "We thought we could optimize a CF/PA6 layup to be as performant as the current CF/epoxy we use, and this was the goal of the project."

Another objective was to develop the process. "To make the whole part from TPC was a big challenge," says Eric Allard, mechanical engineer for composites development at LxSim. "I come from the ice hockey industry, and we tried to do this in the past. But it's not easy to create an optimized preform and then keep the fibers straight as you mold the part."

He explains this is because TPC materials are rigid at room temperature. They must be heated to melt temperature as they are applied to create a multidirectional stacked laminate and then molded into a final part. "We developed a process that uses AFP to create the laminate and then we rolled that preform around a mandrel to form a shaped preform which was then bladder molded. There were also challenges with bladder materials because the TPC molding temperature is higher than with CF/epoxy.

Another issue was finding a high-temperature release layer for the first ply during AFP. The team used Thermalide (Airtech, Huntington Beach, Calif., U.S.), a polyimide release film for temperatures up to 405°C, and an 8-harness satin glass fiber fabric from BFG Industries (Danville, Va., U.S., a subsidiary of Porcher).

"It was a good learning experience for all of us," adds Mathieu, "to go from the raw tapes to the 2D engineered blank rolled into cylindrical-shaped preforms and then final molding of the hollow seat post. We worked a long way up the learning curve and matured the process to get good compaction and control of the fiber angles and gaps."

Simulation to optimize the part

With initial testing and material selection completed, LxSim began to optimize the layup and part for producing the final demonstrators. "We had developed the FEA model of the seat post," says Allard, noting the post is typically round and inserted at an »

Rilsan UDX

Mitsui CF/PP

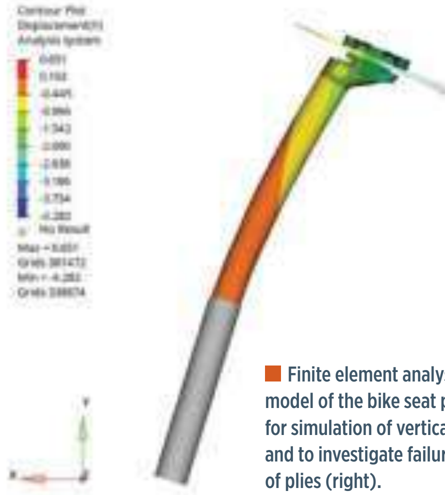
Maezio CF FR 1000T

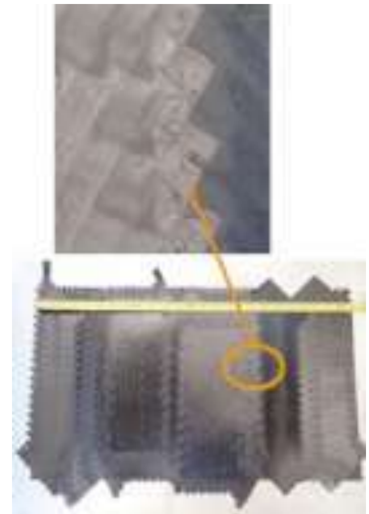
Gordon CF SGL T140/PC

Toray Cetex TC910

Suprem T 50% T700SC-60E/PA12

Six different carbon fiber-reinforced thermoplastic composite (TPC) tape materials were tested using automated fiber placement (AFP) to make plaques for coupons.





Finite element analysis (FEA) model of the bike seat post was used for simulation of vertical load testing and to investigate failure at the ends of plies (right).

angle between the bike frame and saddle/seat. "We defined the boundary conditions and the key load cases and then we virtually tested the part in FEA, loading it vertically from the seat, but replicating the offset, which results in bending and compression on the post."

"There's also a clamping on the frame," adds Lemay, "which creates a highly compressed area. That's why this post was a great demonstrator, because it included a lot of the failure modes that we can see on a bicycle component." Both LxSim and Argon 18 used Hyperworks (FEA model) and Optistruct (solver) simulation software from Altair Engineering (Troy, Mich., U.S.).

"We had the reference layup for the CF/epoxy seat posts, so we had their stiffness and weight," says Allard. "And those were our targets for developing the new layups, considering the stiffness-to-weight ratio of the CF/PA6 and CF/PC materials." He notes there were some drawbacks with the PA6 and PC material stiffness not being as high as the CF/epoxy. "However, we could match this performance including fatigue loading by optimizing the TPC layup. But we needed to make sure we wouldn't get other failure modes."

LxSim came up with two different layups similar in stiffness and weight. "We used a total of 14-16 plies depending on whether it was PA6 or PC," says Allard. "And the reference part in CF/epoxy was 20 plies." Although the laminate was not quasi-isotropic, it did have fiber orientations starting at 0° and rotating at 15° increments. "So, we could tune the fiber angles, and though it's possible to do fiber steering with TPC tape, we didn't try it in this project."

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These layups were then used by CDCQ to optimize the process. "Working with the team at CDCQ, we developed a way to translate the optimized layups to an AFP-produced laminate," says Allard. "We had to make a prototype to get correlation between the FEA and the actual layup. We then had to make some adjustments."

"The PA6 laminate was right on target," he continues, "but the PC laminate needed iteration. That shows why it's good to do the material characterization in the beginning to feed the FEA — it reduces the trial and error and development time to achieve all the targets. Those flat panels were then formed via a rolling process over a mandrel to make the preform that was bladder molded into the final part. So, the whole process started from a flat laminate with staggered plies."

Why staggered plies? "We needed a kind of step joint where the flat panel met itself to form the tube," explains Allard. "And those had to be distributed around the tube. When we rolled these plies to make the tube, we needed to see if we would get any failure at the ends of the plies or any defect in the shape. In the end, it worked fine."

Manufacturing the demonstrators

It took 20 trials to reach an acceptable part, during which a variety of issues were addressed, including bladder leaks, mandrel sizing and the rolling procedure for applying plies to the mandrel. "That was not as straightforward as with CF/epoxy prepreg, where the laminate is applied onto the mandrel ply by ply," notes Mathieu. "With TPC, you have a semi-consolidated layup, so the rollup process is not as tight because the plies are all there already and the TPC tape is more rigid, even when heated. So, we had to go more slowly and really work with the material." In the end, the team was able to make a part with the designed dimensions, achieving good compaction while minimizing voids.

Mathieu points out that for the tooling, CDCQ worked with a partner R&D center, St. Clair College (Windsor, Canada). "The tool was partially designed and machined by mechanical engineering students who also helped out in the manufacturing of the tubes as part of their composites training program," he says.

After bladder molding, CDCQ also trialed fusion welding a bracket onto the seat post, which went relatively well, says Mathieu. "After we consolidated the tube in the bladder mold, we had a different tool we put on the end of the seat post and into which we placed a bracket made from compression molded tape scraps. We then closed the tooling and heated in the press so that we basically co-melted and fused the two parts together."

"This small bracket connects the saddle to the post," adds Lemay, noting that such features on bike frames are mostly compression molded using thermoset composites. "So, it was good for us to demonstrate it with TPC. Normally, it's a solid part that comprises a complex layup of small pieces and stacks of plies, but we used the leftover pieces of TPC tape from the AFP process, which could enable a closed loop recycling process in-house."

On par with epoxy, future developments

After producing the demonstrator seat posts, Argon 18 tested them on its in-house test bench. This included clamping tests where the seat post must withstand 200% of the 4 newton-meter clamping torque. Demonstrators from both the CF/PA6 and CF/PC materials passed, but the maximum clamping torque was 19% higher for the latter.

Seat posts were made by wrapping a 2D preform around a Mosite1453 silicone bladder (left) and placing into a matched metal mold and heated press (above). The gap between the preform and mold (red arrows) must be near zero for good material compaction.

Next, fatigue performance was tested, applying 100,000 cycles of a 1,200-newton vertical load. In this test, the TC910 CF/PA6 seat post passed while the Gordon 40-150 CF/PC post narrowly failed, perhaps to a processing imperfection. Unfortunately, this post could not be included in the subsequent static load tests, where a maximum load of 2,000 newtons was applied for one minute at an offset of 70 millimeters. The TC910 tube passed. However, both posts passed rigidity tests, with results within 8% of the reference CF/epoxy seat post.

"The results showed that it is possible for us to produce a TPC part that's as good as our current CF/epoxy parts," says Lemay. Argon 18 will also test the TPC demonstrator seat posts on an instrumented bike to characterize their stiffness and comfort for the rider in real-life conditions. "We'll use this to characterize the vibration absorption, which is one of the key advantages of TPC compared to thermoset composites for bike frames," he continues. "By early 2025, we'll be able to compare this performance to our current CF/epoxy, in different types of cycling conditions."

Lemay thinks that eventually, even high-end road racing bikes will be manufactured using TPC, "but the roadblocks are how to easily fine-tune the plybook to achieve the performance we want. For Argon 18, we won't target the high-end products at first but instead the mid-range. From our initial simulations, I think it's possible there to achieve the same performance at the same price point, but there's still a lot of work to do before we could put this into production."

"We do see a big shift coming in the cycling industry," says Lemay. "Everything is geared right now to use thermoset composites, but we've seen companies start to use TPC in mountain bikes and Rein4ced is also working with it in road bikes. But there are also significant challenges in developing the manufacturing processes. You can't just go and buy the equipment off-the-shelf. It's not there yet. So, we need to develop the recipe and the equipment according to what we need, and that's why this type of project was so valuable — to collaborate with the CDCQ's technological center, LxSim's simulation expertise and Addcomp's industrial expertise was a win-win for all of us."

For Addcomp, this project proved that innovative systems like AFP can be democratized to industries like sports and leisure and also to smaller companies, says Bonnefon. "It was a great demonstrator for the affordable, customized robotic cells that are now available, which can enable companies like Argon 18 to use more advanced and automated composite technologies."

And will Argon 18 continue forward with this development? "We achieved our initial goals and now we're working to further refine the process," says Lemay. "We have a separate project working on more advanced thermoforming and to see where we can push the layup optimization for even further performance." CW

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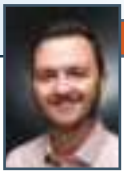
Overall composites index contracting faster than previous month



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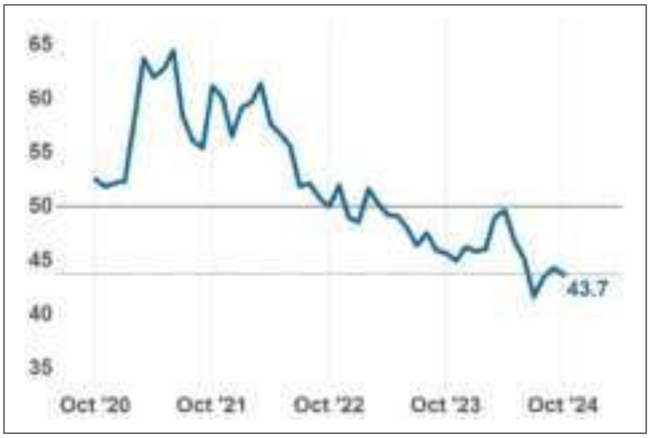
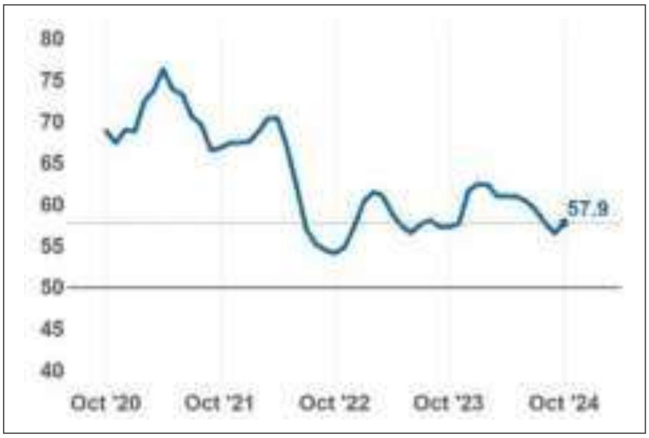
COMPOSITES FABRICATING INDEX



The Gardner Business Index (GBI) is an indicator of the current state of composites fabricating considering survey responses regarding new orders, production, backlog, employment, exports and supplier deliveries. Over 50 is expansion. Under 50 is contraction.

FUTURE BUSINESS INDEX



The GBI Future Business Index is an indicator of the future state of the composites fabrication market considering industry respondents regarding their opinion of future business conditions for the next 12 months. Over 50 is expansion and under 50 is contraction.

COMPONENTS SCORECARD

The GBI Components Scorecard reports the monthly change rate of primary composites market factors contributing to the overall monthly index reading.

READING THE SCORECARD:

Color indicates *where* a component value falls relative to 50 for the current month. Green is expansion; red is contraction.

Shade indicates a value's distance from 50; the darker the shade, the farther from 50.

Direction indicates a value's change versus the previous time period. Pointing up is always better.

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For additional details on this month's GBI report, please visit the online article.

TRENDS

All-CFRP *Horizon* BWB aircraft responds to airlines' request to fill Boeing and Airbus gap; delivery of upgraded Mikrosam placement head advances Type 4 and 5 hydrogen storage development; a 64-meter road bridge installed with carbon fiber is said to feature a first in modern European bridge construction; and more.

AEROSPACE

Natilus announces *Horizon* blended wing body CFRP aircraft for 200-passenger narrowbody market

Natilus (San Diego, Calif., U.S.) has announced launch of the Natilus *Horizon* blended wing body (BWB) aircraft. *Horizon* will be the company's second aircraft in production, following the 2028 entry into service (EIS) of its *Kona* unmanned cargo aircraft, which has 460 pre-orders. *Horizon*'s EIS is targeted for the early 2030s.

Natilus was co-founded by Aleksey Matyushev and Anatoly Star in 2016 to develop the *Kona* aircraft, a BWB design for companies like UPS, FedEx and DHL to solve the problem of limited volume and high costs in traditional tube-and-wing cargo aircraft. *Kona* will now be joined by *Horizon*, a hyper-efficient BWB aircraft designed to be 25% lighter, provide 40% greater capacity and emit 50% less carbon than aircraft used in commercial aviation today. Both aircraft take advantage of Natilus' mild BWB design featuring a slender lifting fuselage, high aspect ratio wings and twin aft-mounted engines.

Kona

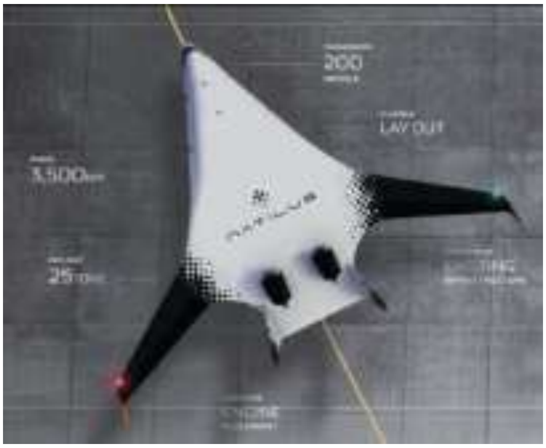
Natilus' inaugural aircraft, *Kona*, is an 85-foot wingspan, 19,000-pound aircraft — which means it can be certified per General Aviation guidelines — with a payload of 3.8 metric tons and a range of 900 nautical miles. *Kona*'s construction is 80% carbon fiber-reinforced polymer (CFRP) composite and 20% metal. The latter is used in *Kona*'s twin vertical tails and control surfaces, while the BWB fuselage will be CFRP. *Kona* will reportedly provide customers with double the cargo volume for each trip, while simultaneously reducing cargo transport cost by up to 60%.

Natilus announced in 2022 that it would partner with Janicki (Sedro-Wooley, Wash., U.S.) for composite part design and fabrication, citing the veteran composites tooling and technology supplier's renowned reputation for innovation and quality workmanship. "We selected Janicki because they are a family-owned and operated company, founded and run by engineers with the highest qualifications and experience in designing large-scale, high-precision prototypes, tools and production parts," says Matyushev.

Initial deliveries of *Kona* with twin Pratt & Whitney Canada (Longueuil, Quebec) PT6A-67D turboprops are expected in 2028. In April 2023, Natilus performed test flights with its sub-scale prototype and has recently completed its full-scale *Kona* prototype which will begin flight testing in 2025.

Horizon

Horizon is a BWB designed for the narrowbody market, accommodating up to 200 passengers and a payload of 25-28 metric tons on routes such as San Diego to Hawaii,



Los Angeles to Boston, and New York to London. Its 118-foot wingspan will meet current limitations at airports, and though weight and payload will depend on the final configuration per customer and mission, the all-CFRP *Horizon* will deliver significant improvements thanks to the inherent aerodynamic and interior volume benefits of its BWB design.

In *Aviation Week*'s report by Guy Norris, Matyushev notes now is the right time to pursue *Horizon* because "the commercial aviation industry is looking for real solutions to become more sustainable, more efficient and more profitable." He adds that this timing "aligns with fleet purchasing decisions by commercial carriers to meet the airline industry's 2050 net-zero goals."

Next steps

While Natilus proceeds with certification and then first deliveries of *Kona*, it will also move forward with finalizing the design for *Horizon*. To meet the target of EIS in the early 2030s, this will need to happen quickly. "That's 6-7 years away, but from our perspective, it's not a lot of time," Matyushev says. "So, we already have wind tunnel testing scheduled for next year, and toward the end of that, we have to freeze the design. Then we'll start working on the internals, systems and manufacturing that will enable us to achieve our first flight goals."

One strategy that will help is the use of already commercialized and available engines, landing gear, avionics and other systems — an approach Natilus is also using for *Kona*. And, as can be seen with Janicki, it is also working with trusted subcontractors.

The company also benefits from an experienced in-house team who have worked on more than 25 aircraft programs spanning commercial, military and general aviation and including innovators from General Atomics, Northrop Grumman, Skunkworks and SpaceX. It is also drawing on the knowledge of its customer partners, which include major airlines, lessors and integrators such as Ameriflight, a regional feeder airline for UPS, as well as Volatus Aerospace, Flexport, Astral, Aurora International, Dymond and others.

The company's key investors — including Draper Associates, VU Venture Partners, Starburst Ventures, Mubadala, Seraph Group, New Climate Ventures, Soma Capital, Type One Ventures and Liquid 2 Ventures — are supporting this next step forward with *Horizon*. "We've been asked by key players in the market to do this," says Matyushev, "and we finally realized this is the right time, which is exciting but also challenging. We see that BWB aircraft have become more normalized and that the market needs new solutions. We're trying to essentially take our design and put it together with existing materials, manufacturing and systems in a unique way that will provide the opportunities and efficiencies our customers want in the near-term."

PRESSURE VESSELS

Mikrosam equips BTU Germany with single-tape AFP head for Type 5 pressure vessels

Mikrosam (Prilep, Macedonia) has announced the delivery of its latest single-tape placement head to the Brandenburg University of Technology Cottbus - Senftenberg (BTU) in Germany, which is an upgrade to the existing robotic multi-tape automated fiber placement (AFP) work cell that Mikrosam delivered to the university 7 years ago. This equipment is specifically designed to meet the increasing demand for precision in automated composite layup processing of Type 5 hydrogen pressure vessels. Optimized for laboratory research and small-scale production, Mikrosam says it offers the flexibility required for producing complex, high-performance thermoplastic composite parts.

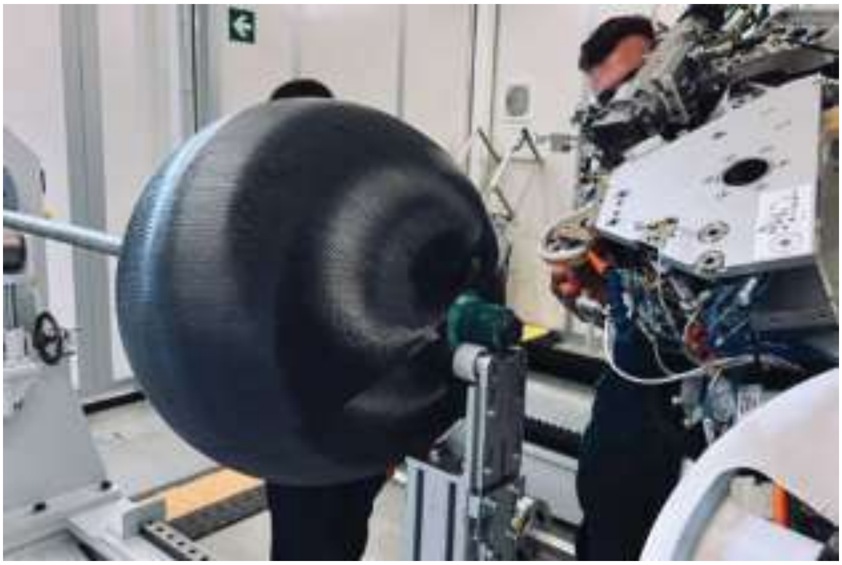
Mikrosam and BTU have a longstanding collaboration on R&D projects, consistently delivering proven results in the composite materials industry. In addition to the placement head, BTU uses a filament winding machine capable of wet and towpreg winding processes, and is equipped with in-house prepreg slitting and rewinding equipment, also manufactured by Mikrosam. This machine is designed to work with thermoset and thermoplastic prepregs to produce spools with various sizes and rewinding styles such as 300-millimeter-wide tape down to ¼-inch tapes used in the university's existing AFP head, and now this new single-tape head. The solution enables on-demand use of prepreg slitting in different AFP processes.

Mikrosam's single-tape placement head is engineered for automated layup on flat and complex, symmetrical or non-symmetrical parts. Its compact design accommodates open and closed mandrel surfaces, making it ideal for cylindrical structures, pressure vessels, box beams and intricate parts with concave and convex geometries. Whether laying down thermoplastic prepreg tapes on flat surfaces or navigating the contours of small-diameter vessels, the equipment is reported to excel in both capability and precision.

Notably, the flexible head is compatible with existing AFP systems, enabling seamless integration with Mikrosam's composite manufacturing solutions. The tape placement technology and thermoplastic material are said to optimize the complete composite design because it can lay and reinforce every angle and portion of the part.

Mikrosam's head is an ideal addition to BTU's R&D laboratory. With it, university researchers can now produce high-performance parts using a wide variety of thermoplastic prepregs, with the system supporting ¼-inch and ½-inch tape widths. These tapes are prepared using Mikrosam's prepreg slitting and rewinding machine, ensuring precise material handling and preparation.

"The layup head is engineered and optimized to achieve a minimum 50-millimeter radius at vessel domes. To accomplish this, the vessel on the tailstock side is supported by rollers rather than a chuck, with long shafts used exclusively on the headstock side," says Vele Samak, VP at Mikrosam. "The head itself is custom designed to produce Type 5 hydrogen pressure vessels in one single, continuous process using automated placement technology and thermoplastic prepregs. Its advanced controls enable real-time adjustments to tape placement angles and compaction forces, allowing users to optimize the process for various applications. BTU will now have the capability to develop and deliver one of the smallest Type 5 pressure vessels for hydrogen in the form of a sphere."



Through the TransHyDE project, BTU's chair of Polymer-Based Lightweight Design, alongside others, is currently researching technologies for the efficient transport of hydrogen for the Federal Republic of Germany. TransHyDE features several projects, each aiming to address a core issue of hydrogen transportation.

One of these projects is Mukran, in which the BTU chair is aiming to create hydrogen pressure vessels, including linerless Type 5 tanks, with innovative geometries to maximize transport efficiency. At the moment, Type 4 tanks are manufactured with various technologies supplied by Mikrosam. The manufacture of Type 4 vessels of particular shapes requires additional flexibility, which is where Mikrosam's new single-tow head system will come into play.

INFRASTRUCTURE

SGL Carbon carbon fiber enables German road bridge milestone

The 64-meter-long road bridge BW399c, located along the A3 highway near Nuremberg, Germany, has been reinforced with SGL Carbon's (Wiesbaden, Germany) 50K Sigrafil carbon fibers. The project, commissioned by Die Autobahn GmbH des Bundes (Berlin, Germany) and designed by engineering company Leonhardt Andrä und Partner, marks a significant milestone in modern bridge construction: An orthotropic composite roadway slab was used in combination with carbon fiber reinforcement on a road bridge, which is claimed to be a first in Europe.

The method of using carbon fiber-reinforced concrete saved more than 60 tons of CO_2 compared to conventional steel composite structures, SGL Carbon reports. Moreover, the weight of the roadway slab was reduced by 55%, bringing it down to just 450 kilograms per square meter. This lightened design also ensures a longer service life for the bridge due to carbon fiber's corrosion resistance.

In addition, the reduced self-weight and prefabrication of bridge segments enabled an overnight installation, minimizing traffic disruptions.

The project was awarded the bauforumstahl e.V. (Düsseldorf) German Steel Construction Engineering Award 2024.

WIND

MingYang completes 20-MW offshore wind turbine installation

In August, MingYang Smart Energy (Guangdong, China) installed the first of its 20-megawatt (MW) wind turbines in Hainan, China, several sources report. The MySE18.X-20MW, capable of operating between 18-20 MW, becomes what the company claims is currently "the world's largest single-capacity offshore wind turbine." Its operation capacity already surpasses the company's 16-MW platform launched in 2023, in addition to competitors like Dongfang Electric (16-MW), Vestas (15-MW), Siemens Gamesa (14.7-MW) and GE Wind's Haliade-X (14.7-MW).

The new platform is characterized by its modular, lightweight design using materials like carbon fiber. The rotor has a diameter of 260-292 meters and a maximum swept area of 67 square meters. At an average wind speed of approximately 18 miles per hour, the MySE18.X-20MW can generate 80 million kilowatt-hours annually.

The MySE18.X-20MW is just the beginning. Reported by *The Maritime Executive*, the company said that it is developing "an even larger 22-MW turbine. The company reports it will have a diameter of over 1,000 feet and it expects to demonstrate the unit by 2025." MingYang adds that, in addition to strong, resilient blades, the turbine will be designed to operate in 19-22-plus mile-per-hour wind speeds.

MARINE

Melker of Sweden accomplishes sea kayak with 100% sustainable composite construction

Melker of Sweden's (Solna) approach to innovation and sustainability has been realized through the Värmdö sea kayak. Its shift toward lightweight, high-performance and plant-based construction has been achieved through the use of Bcomp Ltd. (Fribourg, Switzerland) ampliTex flax fibers, GreenPoxy resins and GreenCoat gelcoats from Sicomin (Châteauneuf-les-Martigues, France) and a cork core. The kayak recently won Product of the Year 2025 in the Sea Kayaking category at the Paddle Sports Show in France.

Melker kayaks are designed and developed in Sweden. Värmdö highlights a sandwich layup with a solid cork core (harvested from the bark of cork oak trees) and flax fiber reinforcement. The structure is vacuum infused with GreenPoxy resins, heat cured and finished with a GreenCoat gelcoat. Melker says this approach provides a combination of high mechanical properties with a design that is "environmentally respectful."

The Värmdö is aimed at a broad range of paddlers — from beginners to experienced paddlers looking for a versatile kayak that can handle everything from relaxed paddling to more adventurous activities like surfing and exploring rocky areas.

For 2025, all Melker models will feature this same construction approach, incorporating Bcomp flax reinforcement fabrics, Amorim cork, and plant-based resins and gelcoats from Sicomin.

In addition to these innovations, Melker is involved in in-house R&D and rapid prototyping using large-scale additive manufacturing (LSAM) for a more efficient product development, and a new plant-based material. "This is significant for us," the company says. "We can listen to the market's needs and quickly 3D print a full-sized prototype in one piece, which we can then field test in natural conditions and under different circumstances. We repeat the process until we are completely satisfied. In the final step, we manufacture molds for efficient and sustainable serial production."

The material used for 3D printing Melker's prototypes is recycled kayaks — shredded and re-compounded with upcycled fishing nets collected on Sweden's west coast, along with wood fibers from Finnish pine forests. Thus, finished products and prototypes are created from recycled, upcycled and/or plant-based materials.

WIND

ZEBRA project demonstrates closed-loop wind recycling system

The ZEBRA (Zero wastE Blade ReseArch) project, led by the French Institute for Technological Research (IRT Jules Verne, Bouguenais) and supported by Arkema (Cologne, Germany), glass fiber supplier Owens Corning (Toledo, Ohio, U.S.), dismantling and waste processing company Suez (Paris, France), the Canoe R&D center (Pessac, France), LM Wind Power (Kolding, Denmark) and Engie SA (La Défense, France) for life cycle analysis (LCA), has demonstrated the complete recycling of thermoplastic wind blades.

The project successfully recycled Arkema Elium resin and Owen Corning's Ultrablade fabrics from wind turbine blades and manufacturing waste, reformulating them back into usable materials.

Each company played a crucial role in the development of the closed-loop recycling process:

- Arkema developed and validated a recycled Elium monomer through thermolysis, achieving a yield of more than 75%. In addition, together with its subsidiary Bostik, an adhesive for the blade assembly that is recycled together with Elium was developed.
- Owens Corning successfully recovered glass fiber at pilot scale, enabling its reintroduction for remelting and reintegration into the production process for Owens' Sustaina product line.
- LM Wind Power manufactured two wind turbine blades with Elium resin and Ultrablade fabrics.
- Suez provided cutting and grinding expertise for processing the blades.
- Canoe R&D center optimized recycling for production and carbon fiber blade waste, additionally developing methods for repurposing via mechanical recycling.
- Engie conducted a comprehensive LCA, demonstrating the environmental benefits of closed-loop ZEBRA blades.

AEROSPACE

Dawn Aerospace reusable rocket-powered aircraft flies twice in one day

In October, Dawn Aerospace (ChristChurch, New Zealand) demonstrated same-day reusability of its rocket-powered aircraft, the Mk-II *Aurora* — which features a composite primary structure — with two flights within 8 hours. The flights took place from Glentanner Aerodrome on the South Island of New Zealand, both reaching speeds of Mach 0.9, 950 kilometers/hour and an altitude of 63,000 feet. These were the aircraft's eighth and ninth flights under rocket power.

The Mk-II *Aurora* is designed to fly to a 100-kilometer altitude, the edge of space, twice in a single day. This is equivalent performance to the first stage of an orbital class two-stage rocket. However, says the company, unlike a traditional rocket, the *Aurora* is certified as an aircraft using a conventional runway and without the need for exclusive airspace.

"Being certified as an aircraft is essential to rapid reusability," says Stefan Powell, CEO of Dawn Aerospace. "Our licence permits us to fly as often as the vehicle allows. At present, we can fly every 4 hours with scope to reduce turnaround time further."

These flights are part of the vehicle envelope expansion program, intended to identify vehicle dynamics in the transonic regime as Dawn works toward breaking the sound barrier. Demonstrating same-day reusability was a secondary goal. In the previous two test campaigns, the company has demonstrated three flights in 3 days.

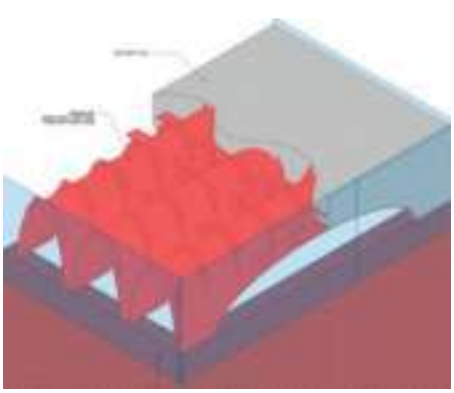
Same-day reusability is an essential part of Dawn's strategy for rapid iterative development, but it also makes *Aurora* well suited for a variety of applications in high-speed flight research, microgravity, Earth observation, atmospheric science and is a stepping stone to the first operational hypersonic vehicles.

CONSTRUCTION

U.S. grant is awarded for patented SIP composites formwork system

Startup ST Bungalow LLC (Garrison, N.Y., U.S.) and Molinelli Architects (Briarcliff Manor, N.Y., U.S.), in collaboration with the Sustainable Materials and Manufacturing Alliance for Research Technology (SM2ART) — a partnership between Oak Ridge National Laboratory (Tenn., U.S.) and the University of Maine (Oreno, U.S.) — have been awarded an Industrial Collaboration grant from the U.S. Department of Energy's (DOE) Advanced Materials and Manufacturing Technology Office, for R&D of a patented "ConTech" stay-in-place (SIP) composites formwork system that can be made from recycled materials such as wind turbine blades.

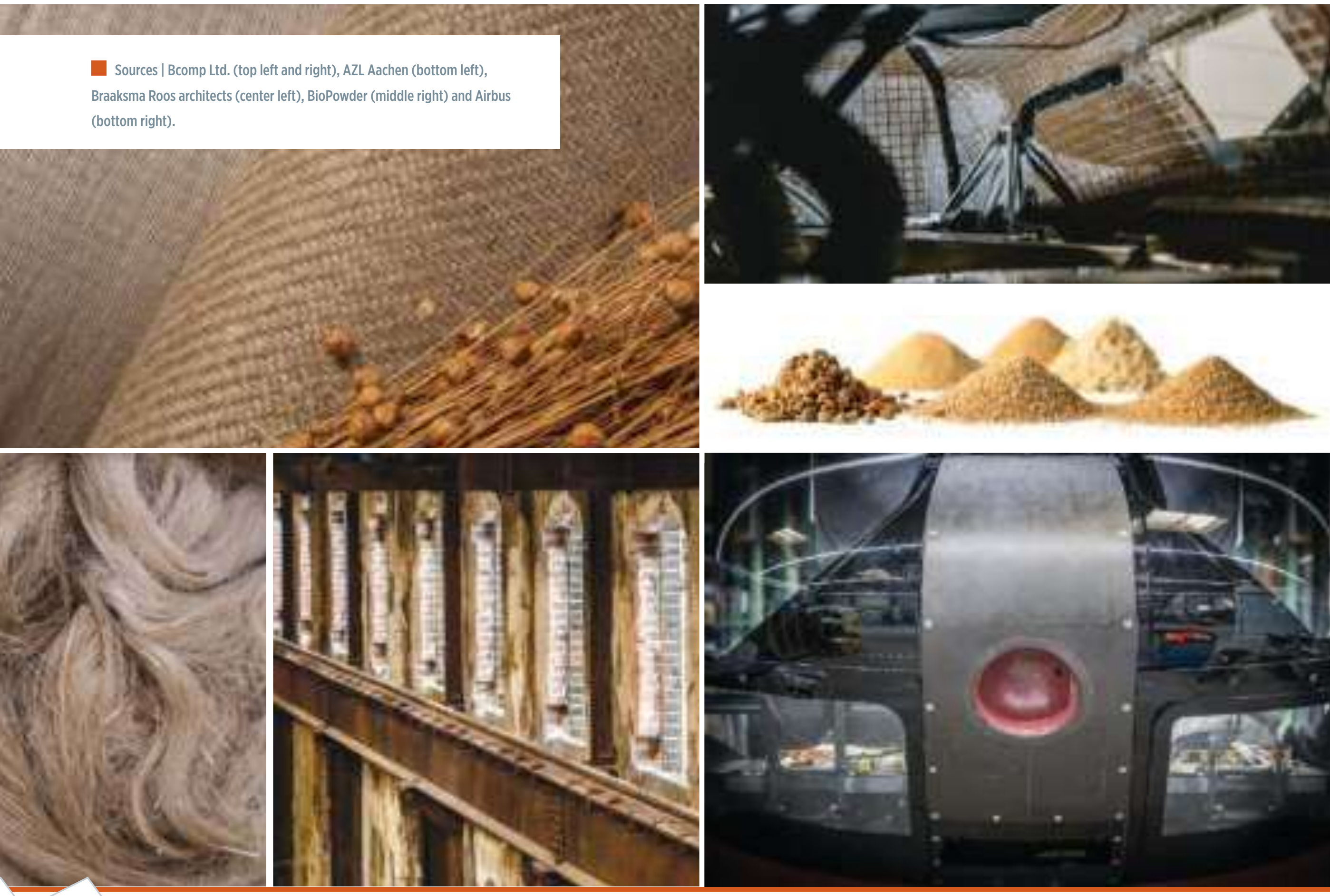
Phase one of the grant, involving computer modeling, was recently completed and now, a phase two grant for a larger sum has been awarded for physical prototypes, scaling up and certification.



Formwork is a temporary structure used in construction to contain and shape freshly poured concrete until it hardens and becomes self-supporting. The ConTech building construction system is designed for reinforcement of concrete flatwork such as floors and roofs as well as infrastructure such as bridge decking. Partners note that the nonferrous (no steel) patent has many advantages over steel rebar and steel decking as well as fiber-reinforced polymer (FRP) rebar. These include significant savings due to the stay-in-place formwork feature which reduces the cost of steel as well as time and labor involved in placing rebar, and also enables the use of recycled materials such as from composite wind blades or boats. ST Bungalow adds that the patent enables concrete to do what it does best — perform in compression.

Moreover, the formwork system has an additional appeal to contractors and architects looking to meet increasingly strict standards and solutions: Its nonferrous aspect avoids problems associated with steel rebar such as corrosion and expansion due to increasingly adverse climate conditions such as heat and increased moisture. Wind blade recycling is a bottleneck in the wind industry and this formwork system has the potential to provide an end purpose solution that consumes enough FRP blade material to actually drive circularity in the wind industry, as well as boating.

ST Bungalow LLC and Molinelli Architects began a joint venture in 2013 and since then have been developing the Contech formwork construction system, including filing patent applications which have been issued and are pending.



Sources | Bcomp Ltd. (top left and right), AZL Aachen (bottom left), Braaksma Roos architects (center left), BioPowder (middle right) and Airbus (bottom right).

Biomaterials make strides toward composites sustainability

A compilation of trends in development and application of natural fibers, bio-based resins and more showcases industry players, educational institutes and global projects.

By Grace Nehls / Senior Managing Editor

» The term "sustainability" was defined in the late 1980s by the UN World Commission on Environment and Development as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." For decades, this concept has been observed, discussed and considered, but there has been little in the way of enforcing it. Arguably, it has only been within the last few years that sustainability has truly been deemed an urgent concern on a more global scale, and as a result, has become a priority for nearly every country. This movement was led by the legally binding Paris Agreement signed in 2015 and has grown ever since, aided by regulations, corporate goals and customer demands.

The composites industry is making considerable efforts to cut emissions, reduce waste, use natural resources and improve energy management — from material development to product fabrication throughout the product's life cycle and its end of life. This pursuit of complete circularity is a complicated and challenging path, and new and ongoing developments are constantly altering what practices are considered "sustainable." Key approaches in composites include the development of biomaterials and recycling as well as energy savings via equipment, sensors and digitization.

In this first article, to be part of an ongoing series, *CW* summarizes some of the biomaterial developments that companies have shared within the last year. Subsequent articles will address recycling and energy-saving initiatives.

Natural fibers and beyond

Materials are the most obvious choice when pursuing sustainability in composites and are being developed in several ways:

- Increased use of natural fibers;
- Incorporation of thermoset or thermoplastic resins that include bio-derived content (e.g., resins and fillers sourced from biomass versus petroleum) and increasing the percentage of what is bio-derived;
- And a combination of these two approaches, including bio-based precursors.

The use of natural fibers — also known as natural fiber-reinforced polymers (NFRP) or natural fiber composites (NFC) — has become a popular choice for companies wanting to provide their customers with sustainable application options. These fibers come from a range of sources, such as plants (hemp, jute, sisal, flax, kenax and bamboo) and even animals (silk and wool), and are characterized by their renewability, less energy-intensive extraction, biodegradability and reduced carbon impact, while still maintaining high mechanical properties like more traditional synthetic options such as carbon or glass fiber.

NFRPs have increasingly graced a variety of end markets, but perhaps none so consistently as automotive, where flax fiber reinforcement in particular decks out everything from aesthetic interior components to safety-critical structures. Bcomp Ltd.'s (Fribourg, Switzerland) ampliTex technical fabrics and powerRibs reinforcement grid have become synonymous with this movement as the company continues its push to accelerate flax fiber adoption in automotive and beyond. Its materials are already being seen on an industrial scale — visible interior components in the new electric Volvo EX30 and the *Polestar*'s interior and exterior flax fiber composite panels; bus A/C covers; and motorsports adaptations like the exterior bodywork components on the BMW M4 GT4. In April 2024, Bcomp closed a $40 million funding round in support of the material's entry into new Asian and North American markets.

Flax fiber producer Groupe Depestele (Normandy, France) is another name in the realm of automotive flax fiber applications. Together with Greenboats (Breman, Germany), the company showcased the Greenlander *Sherpa* expedition vehicle at JEC World 2024, featuring skins, panels and complete structures using dry impregnated natural fiber tapes. In addition, Volkswagen (Wolfsburg, Germany) has entered into a cooperation with textiles manufacturer startup Revoltech GmbH (Darmstadt, Germany) to develop and test a substitute for imitation leather — materials incorporating industrial hemp fibers and a fully bio-based adhesive — for use as surface materials in Volkswagen vehicles starting in 2028.

Along these same lines, the German Institutes of Textile and Fiber Research Denkendorf (DITF) and RBX Créations (Jonzac, France) won an award for the development of a hemp-based pulp that is being further processed into filament-spun cellulose fibers. The raw hemp is grown and obtained locally, which is then processed into a fine-fibered pulp in a process patented by RBX Créations. It's then dissolved in an ionic liquid, which serves as the raw material for a wet spinning process developed at the DITF »

The Greenlander Sherpa is a 6,370 L × 2,170 W × 3,200 H millimeter vehicle highlighting the aesthetics behind the use of flax fiber. Source | Greenlander

Okom's mycelium-based materials offer an R-value of 2.4 (improving insulation properties for energy-efficient construction) and a compressive strength of 1 MPa (for durability and strength), making them 1.1 orders of magnitude stronger and 3.9 orders of magnitude stiffer than other mycelium-based products on the market. Source | okom wrks labs

and patented under the name HighPerCell. The solution is spun into cellulose fibers in a precipitation bath — using a solvent that can be completely recovered and reused — for development of textile fibers, yarns and fabrics.

According to the Alliance for European Flax-Linen & Hemp (Paris, France), 2024's flax harvest reflected positive extraction yields, noting in July that "estimates predict average straw yields of 6-7 tons per hectare for spring flax, a significant milestone that has not been seen since 2019." A successful harvest, of course, suggests plenty of opportunities to meet industry demand.

Exploration and use of other natural fibers, while often still in the maturation phase, show potential for what applications they might attract. A novel material targeting aesthetic purposes (for example, automotive, marine and furniture industries) uses Ohoskin's (Silicia, Italy) leather alternative made from orange and cactus byproducts with ReCarbon's (Busto Arisizio, Italy) recycled carbon fiber. Mycelium composites, typically based on mushroom roots, are being studied as construction material options in academic settings, like the University of Bristol (U.K.) where scientists are fine-tuning their properties and production, or okom wrks labs (Chicago, Ill., U.S.) whose materials "typically incorporate an agricultural residue like hemp hurd as a dispersion phase and fungal mycelium as the matrix phase." The goal is structural mycelium used in applications such as structural insulation panels (SIPs) for construction.

Sulapac (Helsinki, Finland) was founded in 2016 in an effort to safeguard against continual plastics waste. Its materials portfolio includes wood composites — wood fibers from industrial side streams mixed with biodegradable biopolymers — as well as other bio-based materials which can be recycled and include recycled content. They can be mass produced, and are industrially compostable and sustainably sourced, among other advantages. In addition, global automotive supplier Toyoda Gosei Co. Ltd. (Kiyosu, Japan) announced the development of a fiber reinforcement formed from magnesium hydroxide (fibriform) derived from seawater, to be targeted for interior and exterior automotive parts. Surfaces made from this composite are said to be more scratch-proof and require less reinforcement material during manufacture.

Going bio-based via thermoset resins

Bio-based (also known as bio-derived) resins and additives have also become a rapidly growing trend. Rather than simply using natural fibers, companies taking this approach focus either on improving the quality of the resin matrices holding synthetic fibers

PECAN resin has been used to build a 9-meter prototype wind blade to demonstrate its manufacturability. Source | Werner Slocum, NREL

Façade elements for redevelopment of the ABN AMRO building use Duplicor biocomposites. Source | Duplicor

in place or improving the *process* of producing those same fibers.

Thermoset resins in particular have been the composite industry's main target, such as epoxies and vinyl esters. While they have strong mechanical properties and high glass transition temperatures, they are covalently crosslinked, making recycling later in a product's life cycle difficult and expensive, or nearly impossible. Moreover, these types of resins are often developed through petroleum feedstocks, a nonrenewable and thus unsustainable source.

Announcement or launch of bio-based thermoset resins — specifically, resins that are partially bio-derived — has become increasingly common. Exel Composites (Vantaa, Finland), for instance, is aiming to phase out use of hydrocarbon-derived resins on a commercial scale with the purchase of Ineos' (Dublin, Ohio, U.S.) Envirez bio-based resins. The system's chemical composition "features 23% bio-based glycol, compared to traditional crude oil-sourced hydrocarbon resins," representing a 21% drop in associated manufacturing emissions. The National Renewable Energy Laboratory (NREL, Golden, Colo., U.S.) published findings concerning the biomass-derived "PolyEster Covalently Adaptable Network" or PECAN resin developed for recyclable wind turbine blades. Partners found that it performs well with composites, outperforms some resins and enables chemical recycling at end of life (EOL).

Additional developments include Super Resin Inc.'s (Tokyo, Japan) plant-based epoxy resin (a blend of glycol lignin derived from Japanese Cedar and epoxy), Syensqo's (Brussels, Belgium) MTM 49-3 resin that contains 30% bio-sourced monomers to meet automotive sustainability goals and Holland Composites' (Lelystad, Netherlands) Duplicor bio-based, fire-resistant composites. Duplicor has been used in roof structures and façades, for buildings in the Netherlands including Van Gendt Hallen, The Pulse and most recently, the Dutch bank ABN AMRO. "We're using a plant-based resin with a mix of possible fibers depending on the application," explains Eric van Uden, managing director of Solico Engineering, which works with Holland Composites. "And we no longer use PIR [polyisocyanurate] or EPS [expanded polystyrene] foams in sandwich construction, but just recycled PET foam." The latter, he concedes, is not bio-based "but it does help to remove plastics from the environment." Duplicor is now being sold as prepreg and panels worldwide.

Still, other companies have highlighted specific customer applications in which bio-based resin systems are being used, or cite transitioning to sustainable resin use in their own product offerings:

- Polyester resin supplier Büfa Composite Systems (Rastede, Germany) now offers styrene-reduced and styrene-free products, bio-based raw materials and products with recycled raw materials.
- Sicomin's (Châteauneuf les Martigues, France) GreenPoxy 33 bio-resin family has been used for fabrication of eco-friendly twintip kiteboards with flax fiber multiaxial reinforcement, a CNC milled wood core and bamboo rail sections.
- Hexcel's (Stamford, Conn., U.S.) HexPly Nature range of bio-derived prepregs has been transferred to the company's winter sports application production.
- Kautex Textron's (Kautex, Bonn, Germany) Green+ products, made with 20% biomass materials and/or 25% recycled materials, were demonstrated in the form of Pentatonic Green+, a composite electric vehicle (EV) battery enclosure made from fishing nets discarded in the ocean.

CW has also seen trends in applying biomaterials such as lignin to precursor materials in the *production* of resins, including bio-based thermoplastics. For example, a consortium led by sustainable technology innovator Sonichem (formerly Bio-Sep, Southampton, U.K.) hopes to establish renewable,

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Thermoplastics, of course, cannot be forgotten in this discussion, as the composites industry often touts their ability to be melted and reformed into new shapes, making them more recyclable and thus more sustainable. Bio-based *thermoplastic* resins are also being developed for composites and will be addressed in more detail in subsequent sustainability articles.

LEARN MORE

Read this article online | short.compositesworld.com/Biocomposites-listicle

cost-effective alternatives to petrochemicals commonly used in the production of plastics, resins and composites within the automotive industry. This includes converting sawdust, the biomass byproduct from forestry operations, into high-quality lignin to serve as the basis for bio-based platform chemicals. Another example is the intensive development work between Synergy Horizon Poland (Dabrowka, Poland) and KraussMaffei (Laatzen, Germany) that has resulted in the development of bio-based PLA using 30% hydrolized lignin during the extrusion processes. KraussMaffei demonstrated the natural material's incorporation first through its laboratory extruder, a ZE Blue Power 28, and also the company's small ZE Blue Power 42 production compounder.

Evaluating bio-based precursors

Not only are bio-derived resins being considered, but the processes used for synthetic fibers — primarily carbon fiber — are being re-evaluated. Historically, carbon fiber has been produced from a variety of non-renewable precursors, including polyacrylonitrile (PAN), rayon and pitch. These fibers are chemically treated and carbonized to create the high-strength fibers many manufacturers use today. However, bio-based precursors such as lignin or bio-based PAN are being increasingly studied and demonstrated, as methods to achieve sustainability in composites manufacturing evolve. DITF is one organization that has been at the forefront of such research using lignin, including water-spun lignin fibers as a PAN precursor alternative and lignin-based protective coatings for yarns and textile surfaces; its large number of competence and technology centers address everything from molecules and fiber chemistry to end-use products.

Other companies in this field have gone — or will be going — commercial with their bio-based PAN alternatives. For example, a biomass-focused acrylonitrile (CAN) production process developed by Southern Research was licensed by Trillium Renewable Chemicals (Knoxville, Tenn., U.S.) in 2023, and is being commercialized for production of ACN and acetonitrile. The biomass, non-food sugars (or carbohydrates) known as xylose and glucose are harvested from wood-based biomass. Trillium has since been aiming to construct a market-scale demonstration plant in the U.S.

Through another approach, Airbus (Toulouse, France) flew a bio-based carbon fiber helicopter nose panel (see opening image), which was developed using bio-based CAN precursor produced by the Airbus team. The alternative CAN is derived from International Sustainability & Carbon Certification (ISCC)-certified non-fossil feedstocks such as wood and food waste, recycled cooking oils and/or algae, as well as renewable sources of ammonia and propylene. Testing showed that the nose panel offered the same performance as conventional carbon fiber-reinforced polymers (CFRP) but with significantly less CO_2.

A new age of adhesives, additives

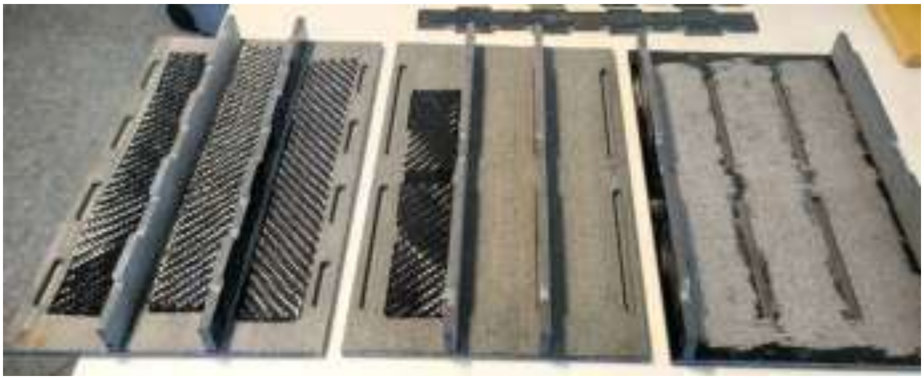
Additives and adhesives, while perhaps not as widely shared as fibers and biopolymers, still have an important part to play when it comes to a composite part's sustainability.

Researchers at the University of Pittsburgh's (Pa., U.S.) Swanson School of Engineering are one group that have taken inspiration from hydrogels, liquid crystal elastomers and mussels' natural bioadhesives to optimize adhesive systems at the molecular level. "This technology is critical for strengthening underwater infrastructure such as platforms and piping," notes Qihan Liu, assistant professor of mechanical engineering and materials science, and one of the project's researchers.

In addition, project partners scattered across northwestern Europe are joining forces under the Biobased Debondable Adhesives (BiDebA) project to engineer bio-based adhesives derived from renewable resources, facilitating composites debonding as well as circularity in transportation markets.

BioPowder (Birkikara, Malta), a specialist in fiber additives and functional composite fillers, provides a good example of how additives can also be sustainable. Its Olea FP line of bio-based and biodegradable functional composite fillers (opening image) are made from upcycled olive stones. They offer features

Water-spun lignin precursor fibers, stabilized and carbonized continuous filaments. Source | DITF



Structure of the wall element through the DACCUS-Pre project, an alternative to reinforced concrete with a particularly good CO_2 balance. Source | DITF

such as high stability, low water and oil absorption, hardness and abrasion resistance and come with a variety of texture effects.

Fiber *and* resin sustainability focus

Sustainability has also fueled a variety of ongoing projects where consortia attempt to address the *entirety* of a composite material system. One example is EOLIAN, a result of the intense and extensive effort to recycle wind turbine blades. This EU-funded project will develop blades that are both repairable and recyclable via bio-based vitrimer resins and basalt fibers with integrated sensors to enable structural health monitoring (SHM).

The SUSPENS project is tackling the challenge of reducing the environmental footprint of sandwich composite and hollow structures manufacture in automotive, nautical leisure and aeronautics. Its first year was dedicated to material development, specifically resins with more than 95% bio-sourced epoxy and polyester, combined with sustainable reinforcements made with natural fibers and recycled carbon and glass fibers. The remainder of the project will validate materials performance via coupon testing.

Meanwhile, a wall element demonstrator made for the DACCUS-Pre project led by the DITF features a novel composite material made from natural gabbro stone, lignen-based carbon fibers and biochar as an alternative to reinforced concrete for use in construction materials.

The CUBIC project, a research and innovation initiative begun in September 2023 and led by the Aitiip Technology Center (Zaragoza, Spain), is focusing its efforts on bio-based intermediate formats — such as filaments, sheets (organosheets and unidirectional tapes), granules and powder — and their combination, in the hopes of overcoming current technical sector limitations. It is considering aspects such as technical design, materials to be used, processability and life cycle, and so far has created different types of bio-based polyamide, carbon fiber and epoxy resin.

Also of note is the BioStruct project, led by Spanish research center Ideko (Elgoibar), where European partners seek to solve the technical problems associated with the use of bio-based composites in industrial structures for sectors such as wind energy or maritime by 2026. While its aim is more to boost the use of natural fibers and biological resins rather than develop new options, this study will still contribute to the "understanding of the mechanical properties of bio-based materials to accurately design structural components and enable their use in such applications."

In addition to all of these research projects, there are some companies already making parts commercially with bio-based resins *and* fibers. Greenboats GmbH is a key example. Founded in 2013, it has positioned itself not just as a boat manufacturing company, constructing vessels from flax fiber and bio-based resins, but as a *technology* company specializing in natural fiber composites. The company is continuously adapting its offerings, currently spanning high-volume production of sandwich panels to high-finish, sustainable campers.

Biomaterials are here to stay

Even with progress being made in this field, there are still many challenges for biocomposites to overcome. For example, depending on the material, they still tend to be higher in cost than more traditionally produced/fossil fuel-based composite materials and may not always be readily available in the volumes that the industry needs (e.g., flax fiber availability depends on crop yield within a given year). In addition, not having the necessary data regarding their performance — particularly regarding their large variety of constituents — has become a large barrier to some biomaterials' consideration and selection for commercial applications.

Regardless of the challenges, the continued development and commercialization of more sustainable composite materials within this wide spectrum — natural fibers, bio-based precursors, 100% or bio-based thermoset resins, and bio-based adhesives and additives — shows a lot of promise in moving the industry's environmental efforts forward. CW

AUTHOR'S NOTE: *This is a only a small portion of sustainability activities taking place in the industry. Visit* ***compositesworld.com/kc/sustainability*** *for updates.*

ABOUT THE AUTHOR

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JEC World 2025's theme "Pushing the Limits" aims to highlight and celebrate achievements in the composites industry that go above and beyond what has been traditionally considered possible.

JEC Group looks ahead to JEC World 2025

JEC World will celebrate its 60th year as the premier international trade show for the global composites industry. *CW* interviews JEC CEO Eric Pierrejean to get a preview of what's in store for the event's 2025 installment.

Eric Pierrejean, CEO, JEC Group.

Source (All Images) | JEC Group

By Scott Francis / Editor-in-Chief

» Eric Pierrejean, CEO of JEC Group (Paris, France), the organizers of the JEC World international composites trade show, recently sat down with *CW* to discuss the event's upcoming 60th anniversary. With six decades of history behind it, JEC World has evolved alongside the rapidly growing composites industry, becoming a global meeting point for this dynamic sector. In our conversation, Pierrejean shares insights into the industry's recent history, the key trends and challenges it faces today, and the highly anticipated innovations and collaborations that will be showcased next year at JEC World 2025 as the event aims to "push the limits" of what's possible with composite materials.

This year marks an important milestone for JEC World. Can you talk about its significance?

JEC World started in 1965, so we'll be celebrating the 60th anniversary of the event, which began as a composites conference in the 60s and then evolved to become JEC World [as it is known] today. It's come a long way and it mirrors the growth of the industry. When I say we are celebrating, we're not just celebrating JEC World. We are celebrating the growth of the industry and what it has become over six decades. I think it's a good point in time to highlight that.

What do you think are some of the biggest changes that have occurred in the industry during that time?

When we look at statistics about the volume of composites production over the years, the great thing you see is that the industry is regularly opening new markets. Composites have seen greater and faster adoption in many sectors, and you regularly have new doors opening.

For example, there was no wind energy as we know it today in the 1960s — today, it's a huge market for the industry. More recently are hydrogen pressure vessels and all the technologies involved with hydrogen-powered vehicles — this is a new market growing.

Over 60 years, the industry has been able to address new end user markets through various properties. Of course, lightweighting is a key one, but composites have so much more than that to offer, such as corrosion resistance and wave transparency for telecommunications.

Another area of growth has been the globalization of the industry. You have players from all over the world and JEC World in Paris has become the meeting point for this global industry, with more than 100 countries represented along the value chain.

What are some of the biggest challenges and opportunities for this industry at the moment?

There's no doubt that sustainability has become the number one topic — and I mean *all* aspects of sustainability. Composites have always been enablers of sustainable solutions. For example, there would be no wind energy as it is today without composites. Another contribution is the ability to have longer-lasting infrastructure and sustainable construction within the civil engineering industry. So, composites have been able to deliver the promise of more sustainable solutions.

On the other hand, for a few years now, the topic of being sustainable and having a sustainable industry has become a top priority. We've seen so many initiatives including recycling, repairing, the introduction of alternative matrices and fibers, and innovative process technologies to reduce energy and material waste. These efforts have been accelerating.

There is also new vocabulary. Words and acronyms like LCA [life cycle assessment], mass balance and EPDs [environmental product declarations] are now hot topics. The industry must not only work on its technologies but also on these ways of calculating our carbon footprint and reducing it, because the end users are challenging us.

In some areas you have landfill bans, which means that you have to promote recycling or recyclable solutions for products. If you have new taxes like a carbon border adjustment mechanism [CBAM], this means that you will have to calculate and evaluate your CO_2 footprint. These are new topics and a key driver of where our industry is heading.

What is the theme of JEC World 2025?

For this 60th installment of the event, the motto is "Pushing the Limits." We want to highlight people who are going beyond the current boundaries of what is possible. This will likely be showcased via new performance and new sustainable solutions, as well as making things that were once thought impossible — like flying around the world in a hydrogen plane or getting boats to sail at more than 100 kilometers per hour [recently achieved by America's Cup Sailboats]. We want to highlight how composites are enabling us to push the limits, as well as how composites are pushing their own limits in terms of technical features and specifications.

These advancements can only happen with teamwork, because when you have to calculate and evaluate the CO_2 footprint of a final product — whether it's a car, a boat or a plane — there's a long chain of supply that has to be considered. So there's effort to be done by the whole industry to get this data, to measure and to optimize these elements.

Can you talk about the ways JEC World fosters collaboration and the ability to share ideas?

We've always celebrated teamwork. For example, when we created the JEC Innovation Awards program more than 25 years ago, there was (and is) a very strong focus on teamwork and collaborative efforts. It's not only about having a new product on the market — there are plenty of those. We highlight the collaborative efforts and the products that have been developed by a team of experts, from raw materials to equipment manufacturers, in order to make it possible. Some say by working together you can go further than being alone, and I think it's really true in this industry.

Also, we try to facilitate, as much as possible, connections at the global level — connections with different cultures and different countries. Innovation is everywhere. One of JEC's greatest achievements for many years has been our curiosity, looking at solutions coming from Asia, Australia, Europe, the U.S. and so on. This relentless quest for innovations and new players has contributed to the success of the event because we bring them together.

What are some trends in the composites industry that stand to make the largest impact over the next couple of decades?

One is addressing these new sustainability challenges and being able to meet the demands of OEMs. Take, for example, recycled content. How much recycled content will we have in the future? We've been talking about virgin fibers for many years, for decades. But there's a growing market for intermediate products or even fibers that are recycled. We see more and more of that kind of demand coming, and an increasing number of exhibitors are »

JEC World introduced its startup booster in 2017 to recognize and support the composites industry's newest entrepreneurs and innovators.

proposing new solutions in that area.

I would also say there is some evolution in terms of standards, especially recently in the construction sector. For example, the ACI [American Concrete Institute] standards for composite rebar in the U.S. and in Europe, and the upcoming Eurocodes in the EU, are opening a huge market for application of more composites in construction. I think these changing regulatory standards can help a lot in sectors where composites market share is still quite low.

You also have sectors that need a lot of education and a lot of information about the properties and benefits of composites — which we convey — to open the market. It requires teamwork to find the best solutions with some very ambitious targets in mind.

In addition, there's the topic of data and AI. I think of the potential of, let's say, computing new molecules, simulating new products, monitoring manufacturing, creating the digital passport of products, managing the end of life of products and so on. This potential is huge. I often say that this is the invisible part of the industry. You have the materials, you have the equipment, but you also have this data, which is very important. I believe AI will influence and help us to accelerate and be more efficient at all points of the value chain.

LEARN MORE

Read this article online | short.compositesworld.com/JECWorld25-interview

The run-up to JEC World is always an exciting time. Is there something you're particularly looking forward to?

I always look forward to receiving the awards submissions and I'm always excited when we receive the submissions of startups. There are so many startups in the industry, and they know that JEC World is a place to gain awareness — to build connections with the world of composites. They are part of the future of the industry. When we introduced the startup booster in 2017, we had the vision that there are entrepreneurs and innovators that have created companies that will fuel the discussion and the technology flow in the industry. I'm happy to see that looking back at this — let's say the Hall of Fame of startups — we've been able to highlight some of the rising stars in the industry.

To see the awards, to see the achievements, as well as to see the new entrepreneurs — that all feeds into the collaborative nature and new ideas at JEC World. CW

ABOUT THE AUTHOR

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APPLICATIONS

Optimized CFRP gantry beam enhances Ultimate cutting machines

CompoTech, Kongsberg PCS collaboration integrates foam-cored design, automated placement of pitch and PAN fibers to achieve award-winning increase in speed and precision.

A lightweight and high-stiffness carbon fiber-reinforced polymer (CFRP) gantry beam enables the Ultimate's high-speed precision cutting. Source | CompoTech

» CompoTech PLUS (Sušice, Czech Republic) uses its proprietary advanced fiber laying (AFL) and winding technologies to replace steel and aluminum with lightweight carbon fiber-reinforced polymer (CFRP) components, such as telescopic masts, gantries, rotary shafts, spindles, beams and tools for production machinery. Since 2013, an R&D partnership between CompoTech and Kongsberg Precision Cutting Systems (Kongsberg PCS, Kongsberg, Norway) has aimed to reduce operational costs and increase productivity by developing wider, faster, high-precision digital systems for high-volume converters of flat and corrugated packaging and display materials. Over the years, these objectives have evolved a CFRP gantry design that now provides a new level in machine capabilities.

These automated machines feature a gantry beam that enables a gear-driven cutting head to fly back and forth across the wide table, cutting shapes out of the material beneath. This beam must handle the load from the cutting head, as well as its acceleration and deceleration, resulting in a mix of rotational, shear and skewing forces.

Launched at the beginning of 2024, the new Kongsberg Ultimate digital cutting machine features a latest-generation CFRP beam, designed not to simply replace an aluminum part, but to optimize the use of composites and CompoTech's design and manufacturing technologies. The Ultimate has received awards in Europe and the U.S., lauding its quantum leap forward in technology and performance for print and packaging producers.

Production innovation partnership

Founded in 1965 near Oslo, Kongsberg PCS has a multinational presence, with centralized production in Brno, Czech Republic, a global head office and customer experience center in Ghent, Belgium, and North American headquarters in Dayton, Ohio. In 2021, Kongsberg acquired MultiCam Inc. (Irving, Texas, U.S.), a global supplier of laser, plasma and waterjet cutting machines and CNC routers.

As it began working with CompoTech, a key objective for Kongsberg was to reduce operational costs and increase productivity by developing wider cutting systems that could also increase speed and precision. CompoTech worked closely with Kongsberg's R&D team to achieve this. "Our first development was a 4-meter-long CFRP gantry beam for the Kongsberg C6 series, which featured a 25% wider, 3.2-meter-wide table," says Dr. Humphrey Carter, head of business development for CompoTech. "Our CFRP beam had to match the profile of the original aluminum beam to keep componentry consistent but also had to match its deflection even though ours was 1 meter longer. We achieved that, and it worked really well."

"For the Ultimate machine, however, Kongsberg gave us free rein with the section profile to get the most out of the material and performance," continues Carter. "We could really optimize the design for composites, to make it as stiff and light as possible. The final design has the added benefit of being produced more efficiently in a single fiber winding step versus the two-step process required for the C6 series beam."

Foam-cored design, pitch and PAN fibers

For the Kongsberg Ultimate, CompoTech selected its in-house developed foam-core integrated beam structure to maximize stiffness and minimize weight. The final design gantry weighs only 70 kilograms with a modulus of 230 GPa in the main beam laminate and a deflection under load of only 200 micrometers. »

This very high bending stiffness is achieved by placing ultra-high modulus (UHM) pitch carbon fiber axially along the beam, made possible using CompoTech's "true zero-degree placement" technology. "Pitch fiber offers higher modulus than the more typical carbon fiber based on polyacrylonitrile [PAN] precursor," says Carter, "but it is also a more fragile fiber and can lose properties if not handled correctly."

"Our ability to design and manufacture highly optimized structures by placing pitch fiber is a specialty we have perfected," adds Dr. Ondřej Uher, R&D director for CompoTech. Carter notes the Ultimate's gantry beam also uses standard and intermediate modulus PAN fibers plus a standard long-cure epoxy resin. This combination of materials is used to reduce the beam's rotational stiffness wound into the structure before being overwound with the final outer laminate. "This design provides a high level of natural frequency damping which has contributed to the much higher cutting speeds and accuracy in the new Ultimate machine," says Uher.

Increased acceleration with precision cutting

The digital cutting head mounted on the Kongsberg Ultimate gantry traverses the cutting table along aluminum rails. "The rail fixing system runs along the entire length of the beam," says Carter. "The new beam design for the Ultimate's gantry needed to accommodate a larger digital cutting head, which applies up to 50 kilograms of downforce and creates a lot of torsional stress."

"For a cutting table, it is the acceleration that matters most and gives the performance, combined with the stiffness of the gantry beam," explains Thomas Malme, R&D chief engineer at Kongsberg PCS. "Getting the cutting head up to maximum speed and back down to zero again as quickly as possible is more important than the maximum speed."

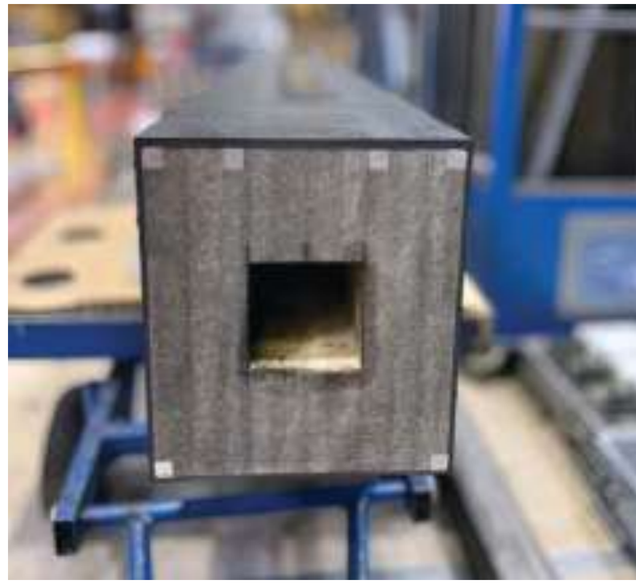
To enable this and the high level of cutting accuracy required, CompoTech developed an approach for affixing these rails to the CFRP gantry beam. This included a system of innovative inserts in the internal structure and machining for accurate mounting surfaces after the beam had been pressed and cured.

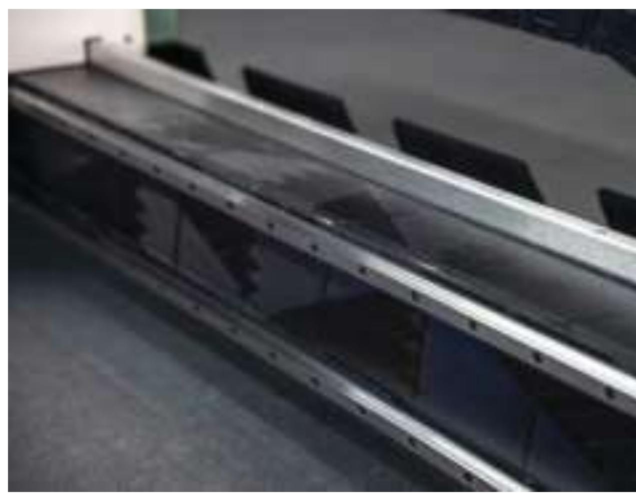
Industry success, future developments

The collaborative approach by CompoTech has been key to the Kongsberg Ultimate's success, says Malme. "We looked at all design areas, both hardware and software, where we could make the Ultimate as fast as possible without compromising cutting accuracy," he notes. "The new high-torque motor drive combined with CompoTech's new design gantry beam is what enables the Ultimate's maximum XY linear acceleration of 2.7 G and linear cutting speeds of up to 2.8 meters per second. With the right cutting tool fitted, it can cut and crease materials up to 30 millimeters thick with a high degree of accuracy."

Carter adds: "The previous design, the C6, was much lower in acceleration, only 7 meters per second, compared to 2.7 G (26.5 meters per second) so it is not really comparable, as we have gone from a 120 × 120 profile constrained by the previous design specification to a 150 × 150 optimized profile."

Kongsberg PCS and CompoTech continue to explore innovative new product developments. "We've been able to demonstrate the advantage when structures are created to make the best use of composites," says Carter. "We look forward to the next challenges from Kongsberg PCS and our continued collaboration." CW





CRFP beam shows aluminum rails affixed by bolts into holes machined through carbon fiber side strips, then bonded to the beam into the aluminum rod inserts. Source | CompoTech, Kongsberg PCS

SHOWCASE/MARKETPLACE

SHOWCASE

MANUFACTURING SUPPLIERS

NEW PRODUCTS

Fiberglass

Multi-end roving enhances SMC capabilities, meets automotive needs

Johns Manville (JM, Denver, Colo., U.S.), a Berkshire Hathaway company, introduces the MultiStar 272 multi-end (assembled) roving to the North American market. Multi-end roving is a fiberglass material in which multiple strands of fiber are bundled together to create a stronger, more versatile product used in composites manufacturing.

MultiStar 272 is designed to meet the automotive industry's increasing demands for high-performance, lightweight materials with high-quality surface finishes. It is specifically designed to enhance the capabilities of the sheet molding compound (SMC) downstream value chain and is said to enable the achievement of stringent Class A surface quality standards, as required by automotive OEMs for their final products.

Achieving Class A finishes presents many challenges, including the need for optimal raw material balance, efficient processing and minimizing surface imperfections. JM points out that MultiStar 272 addresses these challenges with improved wet-out properties, optimized chopping performance and low fuzz formation, ensuring a smooth and defect-free surface.

"Our extensive experience in Europe has shown that MultiStar 272 ensures the consistency and quality required to achieve Class A finishes," emphasizes Pat Reinagel, global portfolio manager fiberglass at JM. "We are thrilled to bring this expertise to the North American market." **jm.com**

Oxidized acrylic fabric

Flame-retardant nonwoven fabric designed for EV batteries

Asahi Kasei (Tokyo, Japan) has introduced a novel material solution for enhanced electric vehicle (EV) battery safety. A flame-retardant and highly flexible nonwoven fabric, Lastan is well suited for use in top covers, busbar protection sleeves and other applications within the EV battery pack to protect against thermal runaway. As an oxidized acrylic fiber, Lastan can also be laminated into a composite surface layer.

There is increasing demand for materials in EV battery cover applications that offer optimal resistance against flames and particle blasts, as well as good electrical insulation properties. While mineral-based materials are generally used as protection against thermal runaway at present, such materials tend to be heavy and brittle. According to Asahi Kasei, these stiff materials are difficult to adapt to complex shapes, making processability an issue for automotive OEMs.

Lastan is a non-mineral flame-resistant fabric made by air baking an acrylic fiber at 200-300°C. It is characterized by high flame resistance and good electrical insulation, which are further improved by a coating process that also augments abrasion resistance. This enables the material to provide effective protection against particle bombardment from venting gas. Lastan has been used as a material for failure prevention and safety in various end markets for many years.

When exposed to a 1300°C flame for 1 minute, Asahi Kasei reports that the temperature on the opposite side of Lastan remains below 400°C and no holes form in the material. While a "limiting oxygen index" (LOI) value of 27 or higher is generally considered to indicate flame retardance, this material has an LOI value of 50 or higher. In UL94 flame retardance testing, Lastan has obtained the highest rating of 5VA.

In addition to its high flame resistance, Lastan offers resistance to high-pressure impact by 200–500 μm particles. It also provides electrical insulating capacity of up to 3.5 kV at a thickness of 1 mm. Lastan features high processability, and is highly flexible while maintaining its performance characteristics in sheets as thin as 0.8 mm. **asahi-kasei.com**

» Molding

FRP molding process augments part cosmetics, mechanical properties

National Manufacturing Group (NMG, Troy, Mich., U.S.) announces the launch of its proprietary molding process, C3 Molding (short for cosmetic capped compression molding). This technology is said to enhance parts cosmetically, mechanically and financially.

The C3 Molding process is fiberglass-reinforced, enabling various lamination schedules to meet specific mechanical requirements. Its 5- to 10-min cycle time enables rapid production of molded, finished parts, which is quicker than other fiberglass molding processes, according to the company. It can also simplify molds in reinforcement ribs and bosses for mounting, providing a smooth B-side finish.

C3 Molding includes a thermoplastic cap, offering options such as high-gloss capped ABS for enhanced UV protection and weather resistance, specifically in exterior applications. For interior applications, a textured low-gloss material is available, featuring a molded-in protective film to prevent minor shipping and handling damage.

For surface protection, NMG says this cap ABS surface can enhance scratch, mar and impact resistance, addressing repairs with a quick polish and buff when compared to gelcoat or paint finishes. This eliminates the need for spray, finish and cure times associated with paint and gelcoat, which can lead to cost savings, as well as offer up to a 50% reduction in part price compared to light resin transfer molding (LRTM) with a painted surface.

Additionally, it enables up to a 50% fill ratio in the resin — catering to FST requirements and heat management — which further reduces material costs. With C3 Molding, users can also see reduced expenses through the use of composite tooling, which is said to cost about half as much as traditional steel compression molding tooling. Plus, a single tool set with the C3 Molding process can produce upwards of 10,000 units per year.

"We've harnessed our capabilities to develop C3 Molding, a process that merges the surface aesthetics and cost-effectiveness of thermoplastics with the versatility and strength of fiberglass. This approach also benefits from the rapid cycle times of compression molding," says Adam Fenton, CEO of NMG. **nationalmanufacturing.group**

» SMC formulation

UV-resistant automotive system enhances SMC part performance

AOC Formulations (Collierville, Tenn., U.S.) has announced its new UV-Resistant System for exterior sheet molding compound (SMC) automotive parts. First presented at SPE ACCE 2024, the innovation combines Atryl closed mold formulations with Chroma-Tek high-performing, UV-stable pigments. AOC's approach involves producing all of the critical materials in-house to enable complete control over the formulation process. The result is a system that delivers the desired composite part specifications and enhances the overall manufacturing process, making it more efficient and cost-effective.

AOC's team of scientists leveraged their extensive experience in chemistry and SMC formulations to address key challenges in truck bed performance. The first step included ensuring the formulation performed optimally during the compounding and molding processes.

According to the company, the resulting system delivers consistent viscosity build, optimal SMC shelf life and improved flow characteristics at high glass concentration, all while eliminating the degradation of the SMC's handling integrity. In addition, the system enables finished parts that meet or exceed expectations for durability, UV stability and aesthetics over time. The system not only includes an ultra-black, molded-in color that resists fading and whitening, but also imparts optimized scratch resistance and low odor for finished parts.

AOC subjected the UV Resistant System to rigorous testing, both in the lab and in real-world conditions, to ensure the performance met the highest standards. This included a battery of tests to validate performance, including accelerated weathering, real-world outdoor

weathering in Arizona and Florida, and scratch testing. Test results confirmed that the system can meet OEM targets for color stability and durability. **aocformulations.com/en-amr/home**

» T-slot framing

Pultruded T-slot option for automation, manufacturing systems

PulFlex Technologies (Ford City, Pa., U.S.) is announcing a direct-to-market 1.5″ × 1.5″ glass fiber composite T-slot framing solution, Flex Connect. Established in 2016, the composites manufacturer focuses on specialty resin systems and fibers, primarily using pultrusion to achieve high-strength, lightweight and fire-resistant parts.

Flex Connect uses a proprietary resin blend and process, which enables parts with properties comparable to metals. The T-slot solution is primarily used for automation, framing and other quick setup systems, such as quick and easy construction of tables, enclosures and other structural systems.

Generally, PulFlex's specialty is polyurethane resins, as well as polyester, vinyl ester, phenolic and resin development. The main reinforcement it works with is fiberglass, but PulFlex also uses carbon and hemp fiber. pulflex.com

» Absolute laser tracker

Versatile, portable laser tracker rapidly measures large, intricate components

Hexagon's Manufacturing Intelligence division (Hexagon, Stockholm, Sweden) introduces the Leica Absolute Tracker ATS800, which combines laser tracking with laser radar functionality to bring traditional reflector-tracking accuracy to noncontact measurement of large, fiber-reinforced polymer (FRP) parts. This means that it is sufficient to perform detailed feature and edge inspections and meet tight assembly tolerances from 10s of meters away, minimizing production bottlenecks on the shop floor.

The technological development enables manufacturers to accurately measure fine edges and features across large volumes. The highly portable system can also reliably measure inaccessible features, such as holes.

"Complementing our laser scanning systems, the ATS800 can cut manual processes from hours to minutes and support the generation of a digital twin," Andreas Werner, CTO at Hexagon's Manufacturing Intelligence division, says. It will be available to all customers in 2025. hexagon.com

» Thermoplastics

LMPAEK thermoplastics now provided in granule, powder formats

Victrex (Lancashire, U.K.) has announced the full commercial availability of its low-melt polyaryletherletone (LMPAEK) granules and powders to all industries. Having already demonstrated success in aerospace composites and additive manufacturing, Victrex LMPAEK polymers are now ready to deliver high-temperature performance, lightweighting benefits and optimal processability across a broader range of industries and applications.

LMPAEK polymers are reported to offer similar high-performance qualities to Victrex polyetheretherketone (PEEK). With improved thermal capabilities and fire resistance, Victrex LMPAEK polymer is suited for demanding applications. The offering of granules and powders is said to enable seamless integration into various manufacturing processes, including 3D printing and composites manufacturing.

The granules and powders provide several advantages. Their lower melting temperatures — melting 40°C lower than Victrex PEEK — enable fast processing times in composites manufacturing, reduced energy consumption and expanded manufacturing capabilities without sacrificing performance. A wider processing window also enables manufacturers to work with a broader range of temperatures without sacrificing the material's mechanical properties or performance. Additionally, the materials are optimized for scalability and cost-effective production in high-volume manufacturing environments. victrex.com

» Design software

Software suite optimizes design of composite pressure vessels

Solico Engineering (Oosterhout, Netherlands) releases the final module of its proprietary software, Amphora, dedicated to the optimization and structural engineering of composite tanks and silos in full compliance with EN13121 standards. The launch of the horizontal tank module completes Amphora's comprehensive suite, which already includes vertical tanks, silos and ribbed vessels.

Amphora is developed as a solution for the design, analysis and optimization of composite structures.

The horizontal tank module is said to expand the software's capabilities, enabling users to design a wide range of tank types with precision and efficiency.

According to the company, Amphora's key features include:

- **Full compliance with EN13121 standards:** Enables accurate and safe designs for composite tanks and silos.
- **Multi-language report exports:** Supports English, Italian and German by default, with additional languages available upon request.
- **Continuous updates and improvements:** Guarantees optimal performance and up-to-date features.
- **Comprehensive suite of modules:** Includes vertical tanks, silos, ribbed vessels and the horizontal tank module.

"This latest addition reinforces Amphora's position as a comprehensive and powerful software for engineers working on composite tanks and silos," says Dante Rogiest, senior lead engineer at Solico Engineering. **solico.nl**

» Bio-based PBT compounds

PBT compounds feature cooking oil monomer, recycled fiberglass reinforcement

Envalior (Düsseldorf, Germany), a Lanxess company, announces the launch of the Pocan X-MB series of polybutylene terephthalate (PBT) compounds — with glass fiber reinforcement — based on bio-circular 1,4-butanediol (BDO). The thermoplastics' sustainable content is certified and classified in accordance with the International Sustainability and Carbon Certification (ISCC) PLUS standard. The BDO precursor is used cooking oil, a second-generation feedstock.

In addition to used cooking oil, other sustainable raw material sources are currently being explored, including postconsumer recycled materials (PCR). According to Envalior, the material innovations have extensive potential in typical PBT applications, such as connectors and housings, as well as structural and functional components.

Three product variants of Pocan X-MB with glass fiber contents of 20% and 30% are currently certified in line with ISCC PLUS. In principle, the entire Pocan range can be produced on the basis of bio-circular BDO, including the hydrolysis-stabilized, flame-retardant and/or laser-transparent product variants. "We will rapidly expand the new product range in close collaboration with our customers," says Marc Marbach, global business director for PBT at Envalior.

The PBT base resin of Pocan X-MB offers customers a sustainable material content of 26%. The company says this proportion can be significantly increased if, for example, PET from postconsumer recyclates and recycled glass fibers (rGF) are used in addition to sustainable BDO. This is the case for Pocan T3230 RC X-MB, which contains a total sustainable share of around 71%.

The carbon footprints of these products are said to be more than 30% smaller than those of equivalent standard compounds. Efforts to calculate these footprints precisely for each compound and make them available to customers are ongoing.

BDO produced from used cooking oil is chemically and physically identical to BDO with fossil-based origins. Therefore, the PBT compounds produced from it have the same chemical, physical and processing properties and the same quality as their counterparts. They meet the same technical specifications and certification standards. In this way, Envalior customers are able to use the X-MB compounds as "drop-in" solutions to substitute equivalent PBT products that are fossil-based, and to employ ongoing production processes.

Envalior notes that the Pocan X-MB series' ISCC PLUS certificate does not apply only in Germany and to circular BDO. It can be extended to all plants worldwide where the company produces PBT compounds.

Envalior has already been offering ISCC PLUS-certified PBT compounds — containing rGF from industrial glass waste, and in some cases, mechanically recycled postconsumer PET — under the Pocan Eco name. Product examples are Pocan ECOB3235 with 30% rGF content by weight; Pocan ECOT3230 with 30% recycled PET (PCR) by weight and 30% rGF content by weight; and the halogen-free, flame-retardant PBT Pocan ECOBFN4231, containing 25% rGF by weight. **envalior.com/en-us/home.html**

Dallara's Formula 2 (F2) seat made from 100% recycled, needle-punched nonwoven carbon fiber.
Source | Dallara

All-recycled, needle-punched nonwoven CFRP slashes carbon footprint of Formula 2 seat

Dallara and Tenowo collaborate to produce a race-ready Formula 2 seat using recycled carbon fiber, reducing CO_2 emissions by 97.5% compared to virgin materials.

By Stewart Mitchell / Contributing Writer

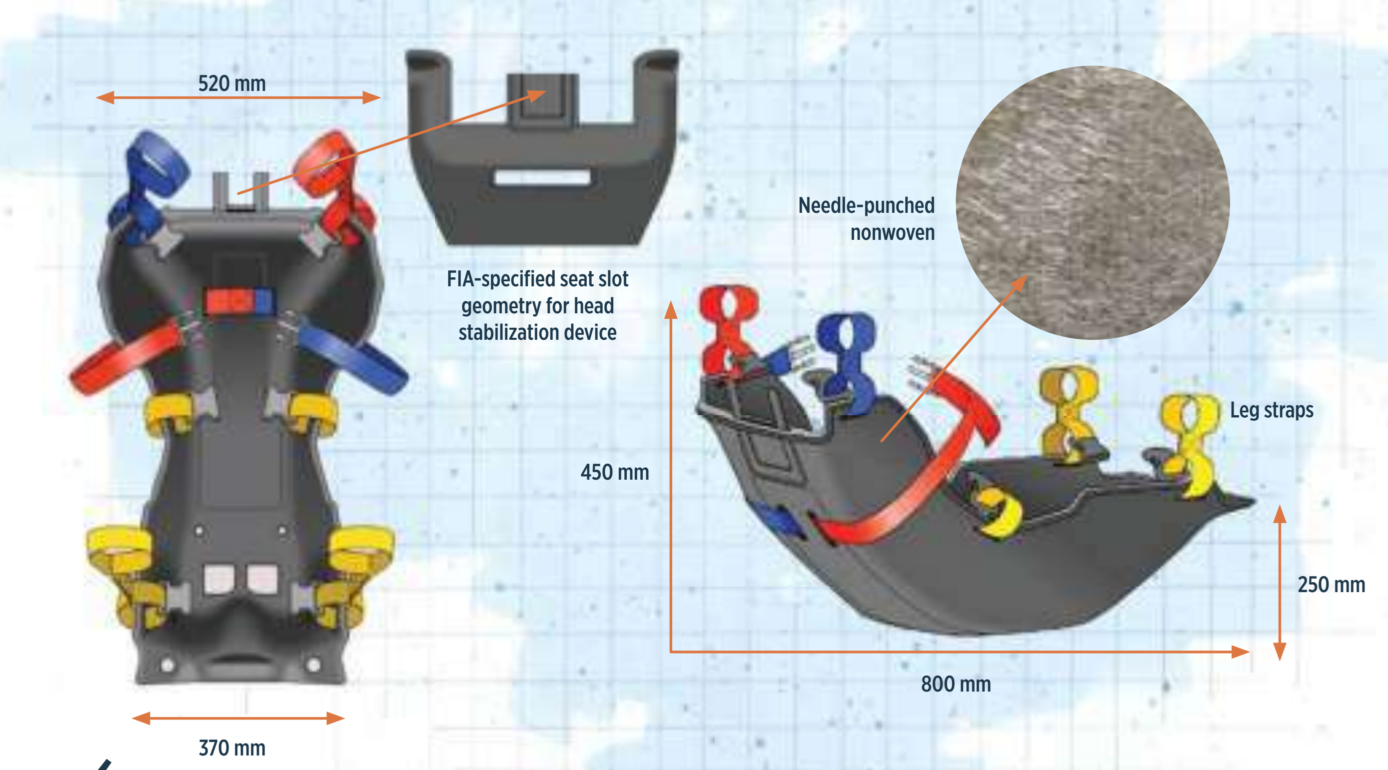
» Formula Two (F2) is the Fédération Internationale de l'Automobile's (FIA) second-tier single-seater global racing championship — just under Formula One (F1), the top-tier. F2 serves as the final stage of the FIA Global Pathway from Karting to F1. It's a spec series, meaning drivers compete in identical machinery to showcase true talent. The Italian race car manufacturer Dallara Group S.r.l. (Varano de' Melegari, Italy) supplies the sole chassis for the entire F2 grid, a carbon fiber-reinforced polymer (CFRP)/aluminum honeycomb sandwich structure monocoque called the F2 2024.

The FIA has recently been on a mission to implement more environmentally conscious regulations throughout the racing series it sanctions, such as reducing the use of exotic materials in car components and powertrains and introducing measures like ethanol blends in the fuel to align with environmental goals while maintaining high performance standards. In a bid to expand the environmentally friendly credentials of F2, in 2024, Dallara collaborated with recycled nonwoven composite specialist Tenowo (Hof, Germany) to develop an F2 safety seat that meets FIA requirements while significantly reducing environmental impact.

The seat, engineered by Dallara, is constructed using 100% recycled, needle-punched nonwoven CFRP and achieves a 97.5% reduction in CO_2 emissions compared to seats made with virgin carbon fiber. This drops seat production from 40 kilograms of CO_2 equivalent per kilogram of material to just 1 kilogram.

Seat specifications and regulations

The FIA's specifications for extractable seats in open cockpit car regulations outline stringent requirements for F2 seat design. Key specifications include shape, head stabilization attachment fixations, straps and buckles and extraction time. The seat must extend from the driver's coccyx (tail bone) to the shoulders,



DESIGN RESULTS **Recycled carbon fiber F2 seat**

- Meets FIA safety standards using 100% recycled CFRP.
- Optimizes seat structure for driver extraction and crash performance.
- Achieves significant CO_2 emissions reduction compared to virgin CFRP.

FIA | Illustration

forming a shell mandated to be made entirely of nonmetallic fiber composite material.

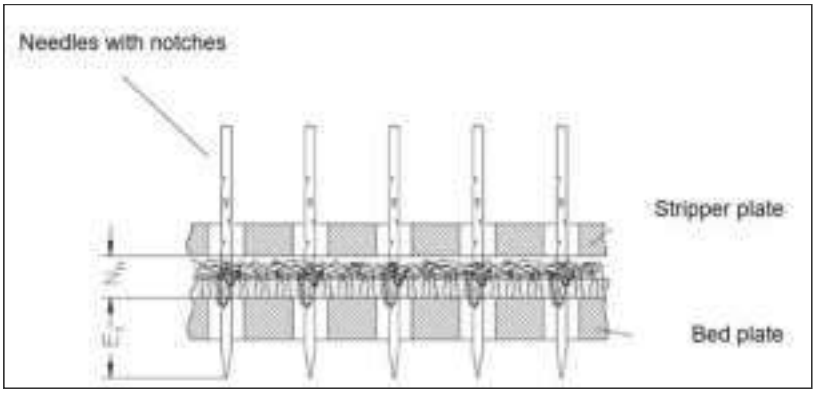
A vertical or near-vertical slot in the highest part of the seat back must accommodate a head stabilization device, with specific dimensions to fit the FIA standard. The seat must also pass an extraction test where it can be removed from the car with the driver strapped in without adjusting the harness, initially pulled in the direction of the car's vertical axis within a given time. These regulations guided Dallara's design process, ensuring the recycled CFRP seat met all safety and performance criteria.

Needle-punched nonwoven rCF

Tenowo's needle-punched nonwoven recycled carbon fiber (rCF) is the F2 seat's key innovation. The manufacturing process involves using secondary carbon fiber from various sources such as edge cuts, loops and trimmings from woven and noncrimp fabric (NCF) production, leftover rovings, textile cutoffs and fibers from end-of-life components.

The process begins by preparing the rCF, which is mechanically or thermally adjusted to a length of 40-80 millimeters and then carded to form a loose web. This initial alignment of the »

Recycled edge cuts, loops and trimmings from woven and noncrimp fabric (NCF) production are used to feed the nonwoven material production. Source | Tenowo



The needle-punching process highlights how a significant proportion of fibers are oriented in the Z-direction. Source | Tenowo

fibers plays a crucial role in determining the directional properties of the final material. Subsequently, the web undergoes a fiber pile laying process, where multiple layers are cross laid to achieve the desired thickness and further control the orientation of the fibers.

The next crucial step is the needle-punch process, which entails mechanical bonding or fixation of the nonwoven materials. Barbed needles are used to repeatedly punch through the layered fiber web. As the needles penetrate, they carry fibers from the top layers down through the material's thickness, creating a complex 3D fiber entanglement. This action significantly enhances the material's structural integrity and mechanical properties.

The needle punching equipment comprises a needle board with thousands of barbed needles, a stripper plate and a bed plate. The web passes between the stripper plate and bed plate, while the needle board moves up and down, driving the needles through the web. The frequency of needle punches, the depth of needle penetration and the advance rate of the web can all be adjusted to control the final material properties.

The Dallara and Tenowo F2 seat production uses a needle-punched nonwoven with a fiber distribution of 40% in the warp direction and 60% in the weft direction. This specific orientation contributes to the material's quasi-isotropic behavior, providing balanced properties in multiple axes.

The process is also responsible for creating a significant proportion of fibers oriented in the Z-direction, which contributes to the material's voluminous nature and enhances its performance in multiple ways. This 3D fiber alignment improves the material's ability to absorb energy during impacts, enhances its acoustic and vibrational damping properties and enables effective thickness buildup with minimal layers.

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Additionally, the unique structure created by the needle-punch process enhances resin penetration during subsequent manufacturing stages. This characteristic not only improves the material's mechanical properties but also contributes to more efficient and consistent production processes. For example, the material's enhanced drapability compared to textiles facilitates easy forming of the complex shapes required in the seat's design.

This needle-punched nonwoven can be produced with a width of up to 2,000 millimeters and a grammage ranging from 100-600 gsm, providing flexibility in design and manufacturing. Recycled nonwoven CFRP typically uses a lower fiber volume fraction (25-35%) when consolidated compared to a woven variant (60%+), resulting in a higher resin content and lower overall density.

Michael Bernegg, head of business development at Tenowo, highlights the sustainability and processing advantages of nonwoven CFRP: "The production of needle-punched nonwoven CFRP requires significantly less energy compared to virgin carbon fiber production, making it an environmentally friendly choice. Additionally, the use of rCF contributes to waste diversion and the enhanced material impregnation properties during molding lead to reduced production cycle times and therefore energy consumption."

F2 seat design, manufacturing optimization

Dallara's F2 seat is produced using a resin transfer molding (RTM) process, which was found to be well suited to the characteristics of the nonwoven material. Manufacturing begins with cutting and layup, where the dry Tenowo needle-punched nonwoven is cut to shape and laid up in the mold, a procedure that takes approximately 30 minutes.

Giuseppe Salemi, head of research at Dallara, explains the layup approach: "We strategically adjusted the fiber orientation of each layer to spread local stress over a larger area, improving overall performance. Additionally, we incorporated localized reinforcements in specific areas of the part."

After layup, the mold is sealed and epoxy resin is injected, saturating the nonwoven reinforcement, a step that also takes about 30 minutes. The part then cures as a result of the epoxy's exothermic reaction, reaching a maximum of 70°C. After a 4-hour cure, the seat is removed from the mold for trimming and finishing.

Micaela Sebastiani, a process engineer at Dallara, emphasizes the value of the wet-out properties of the nonwoven material in the RTM process. "This facilitated efficient resin penetration and minimized void content," she notes. "Initially, several prototypes were developed before achieving the desired consolidation of the fabric and material with minimal waste."

A side view of the F2 seat (above), and bottom-up view after being removed from the resin transfer molding (RTM) machine ahead of the belt holes being cut (right). Source | Faber

"Finally, we were able to achieve a zero-scrap production process, which further enhances the sustainability credentials of the seat," she continues. "The manufacturing process we developed is stable and consistent, with a production capacity of one seat per day."

Testing the seat

In order to meet the FIA requirements for F2 seats, a thorough testing process was necessary. Dallara created its own testing protocol to guarantee the seat's structural integrity and safety. This involved pre-production FEA simulations to analyze material mechanics and extensive simulations and physical tests to optimize the strength-to-weight ratio and to ensure compliance with safety requirements. Additionally, post-production mechanical testing, real-world driver extraction tests and environmental testing were conducted to verify the seat's performance.

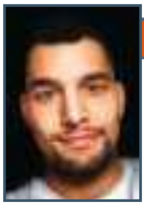
"The focus was on ensuring that the seat could withstand crash forces while still allowing for safe and fast driver extraction," notes Salemi. "Thermal management was also a key consideration, with post-cure treatments conducted on the components to ensure reliable performance under race conditions. The recycled CFRP seat successfully met all FIA requirements."

Sustainability impact, future applications

The implementation of Tenowo's 100% recycled, needle-punched nonwoven carbon fiber has led to a significant reduction in the carbon footprint of the seat. Notably, the success of this project has resulted in wider applications within motorsport — Dallara has already integrated this material into the front wing element of F2 and F3 cars.

Salemi has also indicated plans to expand the use of this material and technology across various sections of race cars, with the ultimate goal of integrating it into the automotive industry. This sentiment is shared by Tenowo, who sees potential beyond motorsport, indicating that initial observations suggest promising performance for lightweight and heat shielding applications in road vehicles. However, the company notes that this technology is still in its early stages, and further research and development are required to fully realize its potential.

The development of this rCF F2 seat demonstrates that high performance and sustainability can be combined in motorsport applications. As the automotive and motorsport industries continue to seek more sustainable solutions, innovations like this seat may pave the way for a new generation of high-performance, low environmental impact composite components. CW



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POST CURE

Highlighting the behind-the-scenes of composites manufacturing

High-temperature carbon-carbon CMC fixtures, racking systems for precise, efficient heat

» Modular composite grids (shown here), used as fixtures and racking systems to hold aerospace, automotive, tooling and industrial parts during high-temperature heat treatment, are made by Americarb (Niagara Falls, N.Y., U.S.) to withstand ultra-high temperatures via carbon fiber and graphite-reinforced carbon matrix (C/C) composites.

With partner High Temperature Concept (Sarasota, Fla., U.S.), Americarb designed and produced eight racks containing four levels of 48 × 48-inch grids from a ceramic matrix composite (CMC) it calls carbon fiber-reinforced carbon (CFC). Equaling 32 total grids with 2.4-inch-deep × 8-millimeter-thick slats, each rack level is rated for a load of 340 kilograms (1,360 kilograms per rack).

Racks are constructed from Americarb's CC16HC2 grade of CFC, featuring a density of 1.65 grams/cubic centimeter and flexural strength exceeding 190 megapascals. These CFC parts are made using in-house carbon fiber/phenolic prepreg, with laminates pyrolyzed in one of Americarb's 18 induction furnaces and/or its large 30 × 40 × 40-foot carbonization furnace.

Americarb also produces CFC cylinders and tubes, fixtures and racks and other products for hydrogen electrolysis, fuel cells, hypersonic systems, launch systems, batteries and vacuum heat treating fixtures. The company engineers, sources raw materials, molds and heat treats parts up to 2900°C, then machines and assembles these in its vertically integrated, world-class facility. CW

Source | Americarb