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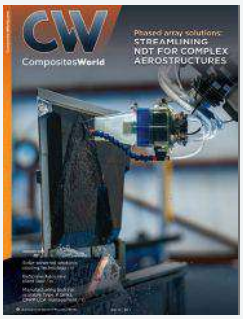

» ON THE COVER

Arcadia Aerospace Industries provides customized, production-based nondestructive inspection (NDI) solutions for a variety of composite applications. One example is an automated 64-element phase array ultrasonic system, which can incorporate multidimensional single-pass scanning applications. The system is capable of inspecting multiple aspects of a part at different frequencies simultaneously, due to its ability to switch between phased array and conventional ultrasonics. See p. 36.

Source | Arcadia Aerospace Industries

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TECHNICAL EDITOR	Hannah Mason hmason@compositesworld.com
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ADVERTISING PRODUCTION COORDINATOR	Becky Taggert btaggert@gardnerweb.com
GRAPHIC DESIGNER	Susan Kraus skraus@gardnerweb.com
MARKETING MANAGER	Chris Saulnier csaulnier@gardnerweb.com

CW CONTRIBUTING WRITERS

Dan Adams	adams@eng.utah.edu
Louis Dorworth	lou@abaris.com
Peggy Malnati	peggy@compositesworld.com
Stewart Mitchell	smitchell@compositesworld.com

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»Welcome to 2024! As is tradition, I want to take this time to review the stories that *CW* has published the past year that garnered the most interest from our print and digital readers. We like to think it offers a small window into some of the trending topics in the composites industry and sets the table for the months ahead.

Trending topics include AAM, hydrogen and sustainability.

Digging through our site analytics, there are many ways you can slice and dice this data. Nevertheless, it's impossible to look at our top article page without seeing one older, albeit still very relevant, story sitting at the top — a 2017 article titled "Composite submersibles: Under pressure in deep, deep waters."

That article was propelled to our most highly viewed story in the wake of the OceanGate *Titan* submersible implosion in June 2023. The event rocked the composites community, as there was much speculation that the use of carbon fiber for the craft's hull might have been a cause of failure, despite the successful use of the material for previous deepsea applications. Six months later, the factors that contributed to the *Titan*'s structural failure remain undetermined. No matter the cause, the event should serve as a reminder that exacting fabrication methods and thorough testing and evaluation of materials and structures are critical for success and safety. As we look to the work ahead for the coming year, that lesson should not be forgotten.

Based on topics of discussion at industry events that *CW*'s editors attended throughout the year, some of the other trending topics of 2023 probably won't come as a surprise. It seems that what is at the forefront of the industry's mind continues to include advanced air mobility (AAM), hydrogen and sustainability. See for yourself with this top 10 list of *CW*'s 2023 most read stories:

- Plant tour: Joby Aviation, Marina, Calif.
- Cryo-compressed hydrogen, the best solution for storage and refueling stations?
- The lessons behind OceanGate
- Plant tour: Albany Engineered Composites, Rochester, N.H.
- Plant tour: Spirit AeroSystems, Belfast, Northern Ireland, U.K.
- Manufacturing the MFFD thermoplastic composite fuselage
- TU Munich develops cuboidal conformable tanks using carbon fiber composites for increased hydrogen storage
- Infinite Composites: Type V tanks for space, hydrogen, automotive and more
- A new era for ceramic matrix composites
- Jeep all-composite roof receivers achieve steel performance at low mass
- Natural fiber composites: Growing to fit sustainability needs
- Next-generation airship design enabled by modern composites
- ASCEND program update: Designing next-gen, high-rate auto and aerospace composites
- Plant tour: Middle River Aerostructure Systems, Baltimore, Md.,
- 3D-printed CFRP tools for serial production of composite landing flaps
- Bio-based acrylonitrile for carbon fiber manufacture
- Novel composite technology replaces welded joints in tubular structures
- The basics of composite drawing interpretation
- MFFD thermoplastic floor beams — OOA consolidation for next-gen TPC aerostructures
- Automotive chassis components lighten up with composites

With the new year ahead of us, *CW* is looking to more exciting stories, events and discussions surrounding these trends. We have two *CW* Tech Days events planned, tackling sustainability and new space, respectively. We're also exploring ways to push the boundaries of *CW*'s reporting by partnering with some of our sister publications. For example, in this month's issue, we are launching a new, semi-regular column inspired by *Products Finishing* magazine that discusses finishing and fastening topics related to composites manufacturing. The first installment discusses an energy-saving coating technology based on photonic cooling.

On behalf of the team at C*W*, I hope you enjoy this issue and wish you much success in 2024. Happy New Year!

SCOTT FRANCIS — Editor-In-Chief

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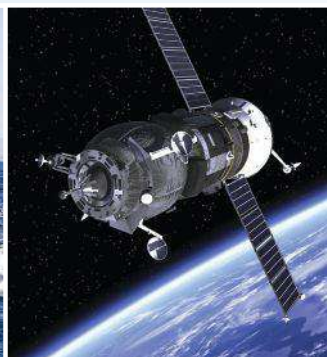

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Damage tolerance testing of sandwich composites: The sandwich CAI test

»Damage tolerance testing of composites refers to the testing of specimens with a centrally located damage site, under a specified loading condition. Typically, the damage is produced by drop-weight impacting, which can cause extensive internal damage that is difficult to detect by visual inspection. For composite laminates, damage tolerance testing is typically performed under in-plane compression loading because their compression strengths are lower than their tension strengths and, therefore, more critical in many designs. Additionally, impact damage typically has a greater effect on the compression strength. The ASTM D7137[1] test method, initially standardized in 1999, is commonly followed for determining the compression-after-impact (CAI) strength of composite laminates. Until recently, however, considerably less emphasis has been placed on developing standardized damage tolerance test methods for sandwich composites.

In 2011, ASTM International (West Conshohocken, Pa., U.S.) published a standardized practice for damage resistance testing of sandwich composites, ASTM D7766[2], which provides supplemental instructions for imparting damage to sandwich composite specimens following either ASTM D6264[3] for quasi-static indentation (Procedures A and B) or ASTM D7136[4] for drop-weight impact testing (Procedure C). In 2022, two *new* sandwich damage tolerance test methods were standardized: a sandwich CAI test and a sandwich flexure-after-impact (FAI) test. In this column, we'll focus on the new compression-loaded damage tolerance test method for sandwich composites, ASTM D8287[5], shown in Fig. 1.

Based on previous research investigations[6-9] and a series of experimental evaluations[10] performed during test method development, a standard sandwich CAI specimen size of 215 millimeters in width and 265 millimeters in length was established. These specimen dimensions were increased in relation to the 100-millimeter-wide and 150-millimeter-long laminate CAI specimen to allow for the larger damage areas produced in sandwich composites and to accommodate the use of strain gages for specimen alignment. Although quasi-isotropic laminates are typically used for laminate CAI testing, the facesheet ply layup and core configuration for sandwich composite CAI specimens are often selected to represent the intended structural application. In some cases, however, the core thickness must be increased to avoid specimen buckling under compression loading. Additionally, potting of the core region at the specimen ends may be required to avoid facesheet separation or end-brooming prior to specimen failure.

Similar to the ASTM D7137 test method for damage tolerance testing of composite laminates, ASTM D8287 requires that the loaded ends of the sandwich specimen are machined parallel within tight tolerances. Four bonded strain gages, mounted onto the facesheets in the loading direction, are used for specimen alignment prior to testing. Based on the results of finite element analyses[10], the preferred strain gage placements are 25 millimeters from the specimen outer edges and either 25 millimeters below the top edge of the specimen or 12 millimeters below the upper potted region, whichever is greater. The standard specimen dimensions and strain gage locations are shown in Fig. 2.

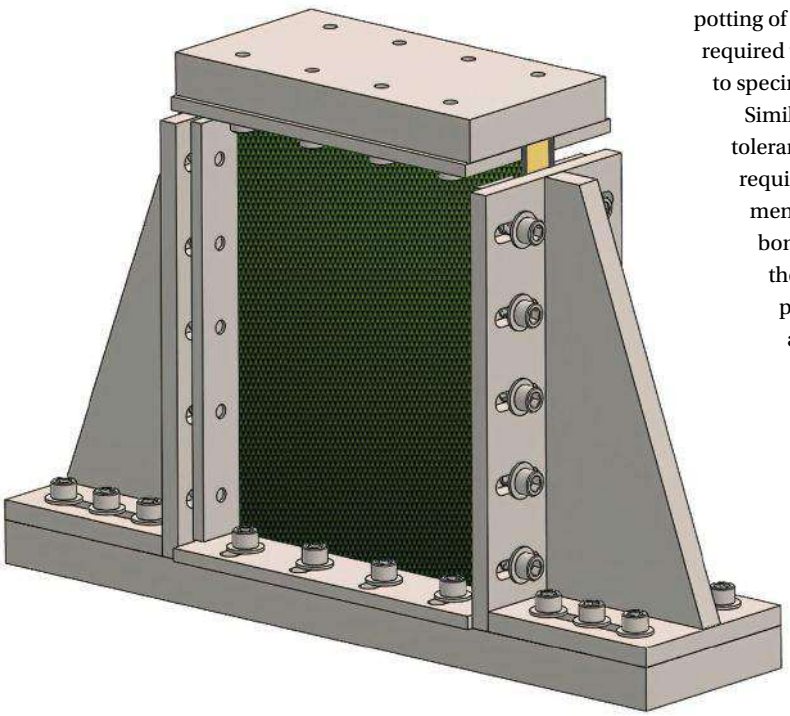

FIG. 1 Damage tolerance test method standardization

ASTM D8287 sandwich CAI test fixture and specimen. Source (all images) | Dan Adams

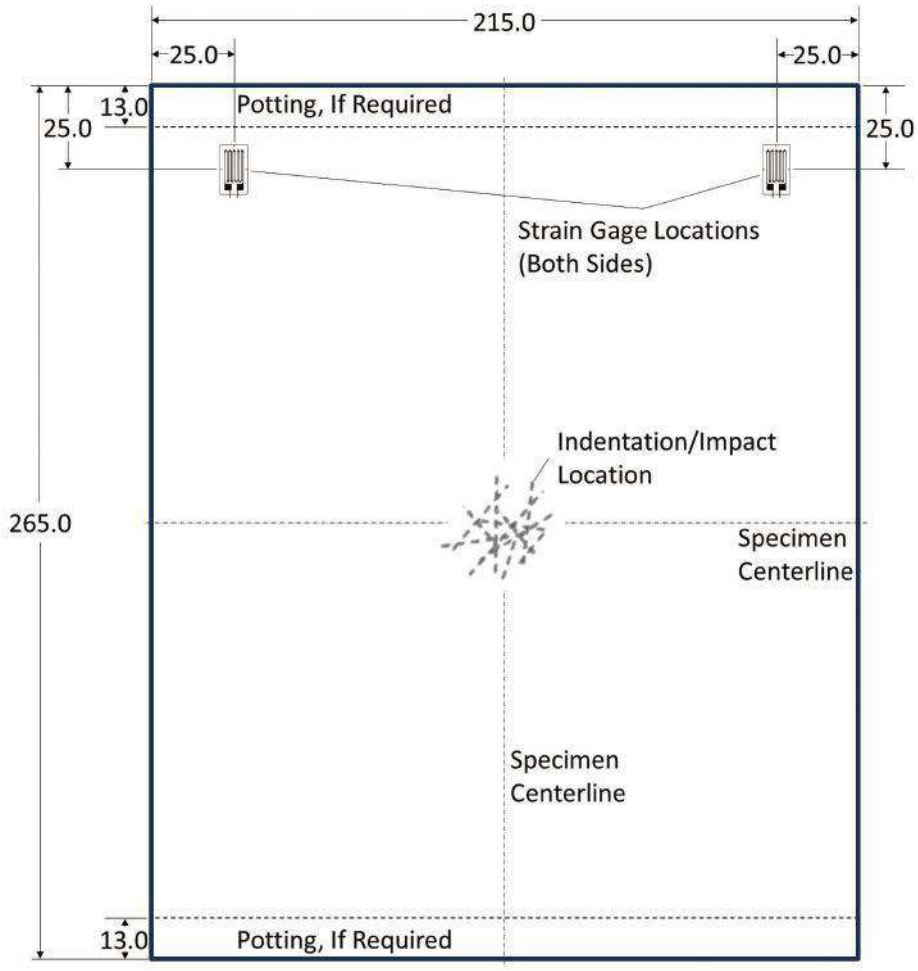

FIG. 2 Sandwich CAI testing

ASTM D8287 standard specimen configuration (all dimensions are in millimeters).

The test fixture used for sandwich CAI testing (Fig. 1) is a scaled-up version of the ASTM D7137 laminate CAI test fixture that can accommodate sandwich specimen thicknesses up to 50 millimeters. The end-loading fixture consists of a base, two vertical supports and a top plate. The base and top plate use adjustable, flat-faced specimen supports that provide some restraint to out-of-plane rotation and prevent end-brooming of the facesheets. The vertical supports use adjustable knife-edged specimen side supports that provide out-of-plane restraint to buckling. The height of the vertical supports is reduced to produce a small gap adjacent to the top plate to allow for the reduction in specimen length during compression loading.

After the sandwich specimen is secured into the test fixture, the assembly is placed between the platens of the testing machine and aligned with the loading axis. A locking spherical-seat platen is recommended, but not required, for specimen alignment using the four bonded strain gages. If a spherical-seat platen is not used, shims placed between the fixture and platens may be incorporated for alignment. To align the specimen, the assembly is compression loaded to approximately 10% of the estimated maximum force and the four strain gage readings are obtained. Differences in strain between the gages indicates specimen bending or uneven load introduction. If the difference in the readings exceeds 10%, the specimen is unloaded and the spherical-seat platen locking screws are adjusted. If a spherical platen is *not* used, shims are inserted between the platens and test fixture. This alignment procedure is repeated until all four strain gage readings are within 10%. The sandwich specimen is then compression loaded at a constant displacement rate and the applied force, crosshead displacement and strain data from the bonded strain gages are recorded. Once the peak force is reached and the measured force drops by more than 30% from the peak value, the loading is halted to help identify the initial failure mode and location for later evaluation. The sandwich CAI strength is calculated using the peak applied force, and the total cross-sectional area of the two facesheets.

Minor end crushing before final failure in the gage section sometimes occurs, but if a valid gage section failure is ultimately achieved, such end crushing does not necessarily invalidate the test — what does invalidate it, however, is the onset of specimen »

instability or excessive bending. Gage section failures away from the impact damage are considered acceptable, and may indicate that the specimen is not sensitive to the induced damage, such that it fails at a compressive stress near the specimen's undamaged strength. While this test method may also be used to test undamaged sandwich specimens for use in experimentally determining strength reductions due to impact damage, care should be taken to prevent undesirable failure modes such as end crushing. Note that the ASTM C364[11] sandwich edgewise compression test, originally standardized in 1955, remains the recommended test methods for determining the undamaged sandwich compression strength. CW

ABOUT THE AUTHOR

Dr. Daniel O. Adams is president of Wyoming Test Fixtures Inc. (Salt Lake City, Utah, U.S.) and an emeritus professor of mechanical engineering at the University of Utah, where for 23 years he directed the Composite Mechanics Laboratory. He holds a B.S. in mechanical engineering and an M.S. and Ph.D. in engineering mechanics. Adams has a combined 44 years of academic/industry experience in the composite materials field. He has published more than 120 technical papers, is chair of ASTM Committee D30 on Composite Materials and co-chair of the Testing Working Group for the Composite Materials Handbook (CMH-17). He regularly provides testing seminars and consulting services to the composites industry. **Dan@WyomingTestFixtures.com**

REFERENCES

[1] ASTM D7137/D7137M-17, "Compressive Residual Strength Properties of Damaged Polymer Matrix Composite Laminates," ASTM International (W. Conshohocken, PA, US), 2017 (first issued in 2005).

[2] ASTM D7766/D7766M-23, "Damage Resistance Testing of Sandwich Constructions," ASTM International (W. Conshohocken, PA, US), 2023 (first issued in 2011).

[3] ASTM D6264/D6264M-23, "Measuring the Damage Resistance of a Fiber-Reinforced Polymer-Matrix Composite to a Concentrated Quasi-Static Indentation Force," ASTM International (W. Conshohocken, PA, US), 2023 (first issued in 1998).

[4] ASTM 7136/D7136M-20 "Measuring the Damage Resistance of a Fiber-Reinforced Polymer Matrix Composite to a Drop-Weight Impact Event," ASTM International (W. Conshohocken, PA, US), 2020 (first issued in 2005).

[5] ASTM D8287/D8287M-22, "Compressive Residual Strength Properties of Damaged Sandwich Composite Panels," ASTM International (W. Conshohocken, PA, US), 2022.

[6] Tomblin, J.S., Raju, K.S., Liew, J., and Smith, B.L., 2001, "Impact Damage Characterization and Damage Tolerance of Composite Sandwich Airframe Structures," Final Report, DOT/FAA/AR-00/44.

[7] Tomblin, J.S., Raju, K.S., and Arosteguy, G., 2004, "Damage Resistance and Tolerance of Composite Sandwich Panels – Scaling Effects," Final Report, DOT/FAA/AR-03/75.

[8] Butterfield, J.M., and Adams, D.O., "Effects of Stitching on Compression After Impact Strength of Sandwich Composites," Long Beach, CA: Proceeding of the 49th International SAMPE Symposium and Exhibition, 2004.

[9] Butterfield, J.M., 2006, "Damage Tolerance of Stitched Carbon Composite Sandwich Structures," M.S. Thesis, University of Utah.

[10] Kuramoto, B., Stanfield, M., and Adams, D.O., "Development and Evaluation of the Sandwich Edgewise Compression After Impact Test," to appear in the *Journal of Sandwich Structures and Materials*, 2024.

[11] ASTM C364/C364M-16, "Edgewise Compressive Strength of Sandwich Constructions," ASTM International (W. Conshohocken, PA, US), 2016 (first issued in 1955).

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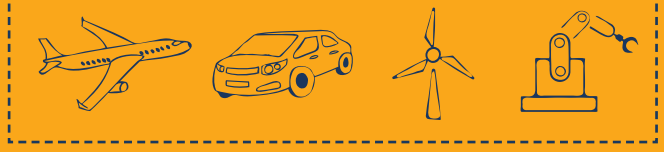

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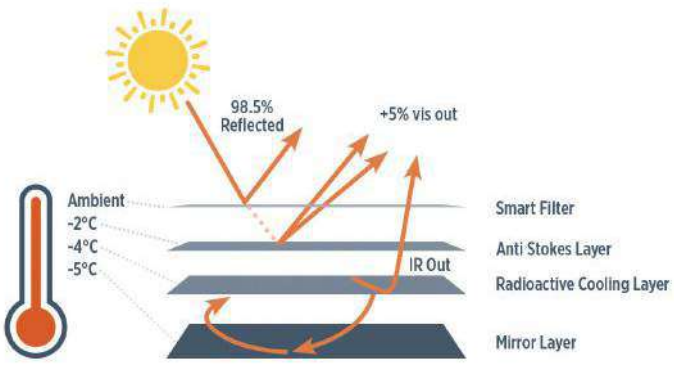
Solar-powered photonic cooling enables energy-saving coating

» The world just experienced its hottest June on record, and 2024 is projected to be even hotter. Cooling accounts for 10% of global electricity demand, which can rise by more than 50% in summer. If every 1°C increase in temperature above 24°C can drive a 4% rise in electricity demand, in Texas, for example — then what might be possible with every 1°C decrease if it was achieved by passive cooling, *without* electricity? An Israeli deep-tech startup known as SolCold (Ness Ziona) has been working on an innovative coating aimed to do just that — to cool the shell of a car, container, airplane or building by 5-12°C, reducing the need for air conditioning, its energy consumption and potential greenhouse gas emissions — using clever physics and the power of the sun.

Passive cooling takes energy from the environment and converts that using physics — evaporation using water, for example, or blackbody radiation/infrared (IR) emissions — to transfer heat away from surfaces without using any power. Passive radiative cooling has been known for centuries and pursued in buildings for decades, but it's challenging to achieve at the hottest times of day because all natural materials absorb more solar energy than they can radiate — even the whitest paint. Founded in 2016 by Yaron Shenhav, Gadi Grottas and Guy Ron, SolCold launched its first product in 2021: a coating material that passively cools surfaces by reflecting sunlight and emitting thermal radiation, but going even further by using the photons that it *does* let through to reduce the energy in the atoms of the coating, effectively refrigerating it. Called Glacier 110, this coating film can be applied to a variety of surfaces, including carbon fiber composites, with the goal of reducing the need for energy-intensive air conditioning and improving energy efficiency.



The cooling effect

SolCold's technology passively cools surfaces by reflecting sunlight and emitting thermal radiation.

Helping to conserve energy

SolCold Glacier 110 film application to an automotive roof panel.

Source (all images) | SolCold

How the technology works

Glacier 110 comprises a top layer that provides wear and abrasion resistance and also reflects 98.5% of solar radiation while amplifying "useful" wavelengths of light. Those useful photons are then absorbed by the next layer, which uses anti-Stokes fluorescence to emit photons back at a higher energy, lowering the energy within the material, and effectively achieving refrigeration. A subsequent radiative cooling layer further augments this cooling effect. The mirrorlike layer on the bottom, explains Shenhav, "is so that everything we are emitting in our upward converting of photon energy goes away from the substrate because we don't want that to heat up."

Glacier 110 is currently available as an adhesive film that can be cut to meet almost any shape and supplied in 50-centimeter-wide rolls. Length can vary, with the maximum being 50 meters, which primarily targets buildings and large structures. The technology offers potential for applications in a wide range of industries such as construction, transportation, agriculture, energy, communications, automotive and aerospace.

Glacier 110's full daylight cooling power is 80-110 watts per square meter sub ambient. Thus, coating the top of a 20-foot shipping container (13.86 square meters) could rival the power of a small window air conditioner (5,000 BTU/hour where 1 watt=3.41 BTU). It does this at a thickness of 350 microns and an area density of 0.29-0.31 kilograms per square meter, weighing 300-400 grams per square meter. The cost of the film ranges from $65-120 per square meter, depending on needs and qualifications.

Current applications

A majority of SolCold's success has been applying its film to metal substrates — it has been used for cars, electronic boxes, rooftops, warehouses and storage containers. The film can also be used for some plastics and composites, provided the substrate has good

Wide industry potential

SolCold Glacier 110 film is available in 50-centimeter-wide rolls of varying length up to 50 meters.

Passive cooling

SolCold's coating technology can increase passive cooling of refrigerated vehicles and shipping containers.

thermal conductivity. Any insulating particles on the surface can disrupt the efficiency in the cooling effect to the interior. In addition, the film also requires surface preparation of the substrate. The surface of the material must be smooth for the film to adhere.

SolCold has trialed Glacier 110 on car rooftops and is exploring use in vehicle interiors. When used in these applications, the technology helped to reduce cabin temperature by 9-12°C. Air conditioning consumption was also reduced by 30% and driving distance increased by 7%. Given concerns over range for electric vehicles, one can imagine the benefits of conserving the energy required to cool these types of vehicles.

Extending life expectancy

SolCold's Glacier 110 film is said to yield a return on investment in cooling cost savings within 1.1 years and exhibits a life expectancy of more than 10 years in construction applications.

Within the construction industry, Glacier 110 is said to yield a return on investment in cooling cost savings within 1.1 years and exhibits a life expectancy of more than 10 years. This offers advantages to building projects seeking Leadership in Energy and Environmental Design (LEED) certification, a globally accepted green building rating system.

Within the electronics industry, Glacier 110 is reported to reduce central processing unit (CPU) temperature by 5°C. According to SolCold, this can translate to up to 50% less maintenance, doubling mean time between failure (MTBF), a measurement of the average up-time of equipment between breakdowns or outages.

One particularly successful implementation of SolCold's technology is in the shipping industry when a cold chain is required. A cold chain is a temperature-controlled supply chain comprising refrigerated production, storage and distribution facilities, supported by equipment that can constantly maintain the required low temperatures. Trucks or refrigerated shipping containers used in a cold chain often rely on a condensing unit, or compressor, and a refrigerant to condition the air and generate the necessary cooling. SolCold's technology can increase passive cooling of vehicles and containers, enabling more efficient use or downsizing of compressors, reducing energy consumption and emissions. In addition, the use of Glacier 110 for the passive cooling of shipping containers can extend the time they can be unplugged from an energy source during layovers at ports or other transition points.

Potential applications

The need for increased cooling efficiency is becoming obvious with the growing development of alternative modes of propulsion. Electric power, whether supported by hydrogen fuel cells or batteries, means limited energy capacity. Every point where energy might be saved counts. As aerospace companies explore electric- or hydrogen-based propulsion methods, passive cooling technology such as SolCold's film could be instrumental in helping conserve valuable energy, thus extending range and reducing carbon emissions.

In the meantime, SolCold is exploring ways to further improve its technology and extend it into a growing number of applications, including aerospace, as well as transportation and defense. CW

ABOUT THE AUTHOR

Scott Francis is the editor-in-chief of *CompositesWorld* and *Products Finishing*. He has written for numerous publications including Writer's Digest, HOW and Popular Woodworking.
sfrancis@compositesworld.com

Composites industry heads into slightly accelerated contraction in November

NOVEMBER — 44.9

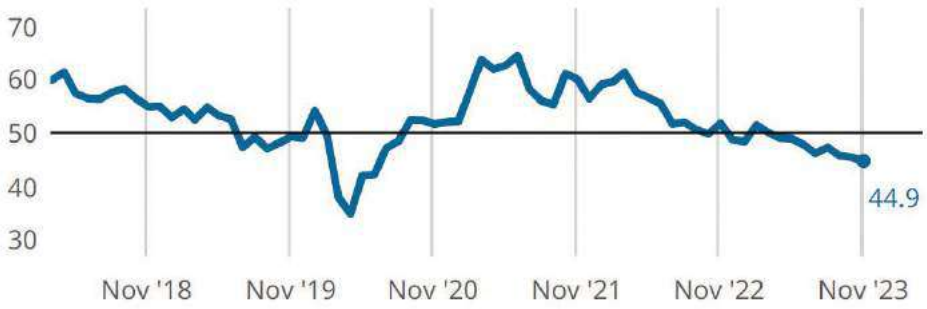
» The GBI: Composites limped along again in November, experiencing minorly accelerating contraction to about the same degree as October, closing at a reading of 44.9 compared to the previous month's 45.6. This general slow-going contraction began in April 2023.

Closely connected composites fabricating components — production, new orders and backlog — primarily drove November contraction. Exports marched along its slowly accelerating contraction path while employment contraction slowed a bit, potentially starting a return to a more normative state following the accelerated contraction that emerged in August. Supplier deliveries continued to lengthen, but at a slowing rate that inches it closer to flat every month. CW

ABOUT THE AUTHOR

Jan Schafer, MBA, is the director of market research for Gardner Intelligence, a division of Gardner Business Media (Cincinnati, Ohio, U.S.). She has been an essential part of Gardner Intelligence for over five years, and has led research and analysis in various industries for over 30 years.
jschafer@gardnerweb.com

GBI: Composites Fabricating

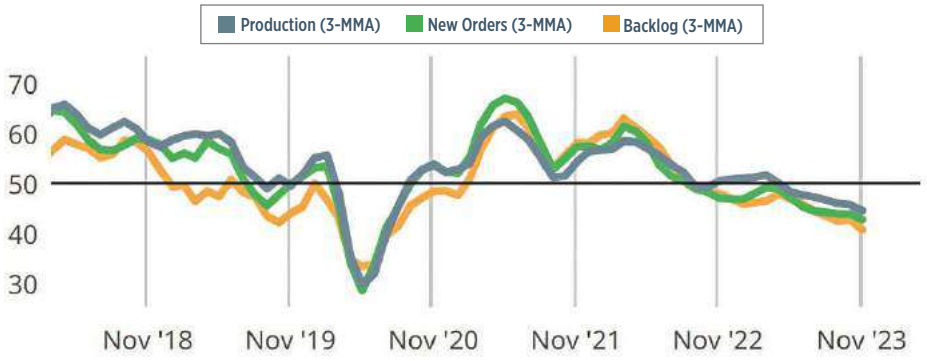


Taking a step back

GBI: Composites Fabricating in November was down 0.7 points relative to October.

Source (all images) | Gardner Intelligence

GBI: Composites Fabricating — Production, New Orders and Backlog (three-month moving average)



Downward spiral

Production, new orders and backlog components drove November's accelerated contraction.

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A new *CW Talks* podcast episode discusses Ford Motor's involvement with the EMPHASIZING project; the German Institutes of Textile and Fiber Research are targeting more sustainable carbon fiber; a deep-tech startup seeks to enhance carbon fiber component recyclability; and more.

Episode 43: Emphasizing the recycling of wind blades

The recycling of composite wind blades from wind turbines is a topic of much debate in the composites community and in sustainable energy discussions. In the latest episode of *CW Talks*, *CW* explores a new approach aimed at the reclaiming and upcycling of some of these materials when the wind blade reaches its end of life. Professor Alan Banks, innovation and industrial engagement supervisor at Ford Motor Company's Dunton Technical Center in the U.K., discusses Ford's involvement with the EMPHASIZING project, a U.K. consortium working to develop a material from recycled glass fiber with mechanical properties superior to virgin glass, but at a price point lower than carbon fiber.

This Q&A is excerpted from the *CW Talks* podcast and is edited for clarity. To hear the entire interview, please visit **www.compositesworld.com/podcast.**

Scott Francis (SF): What are the goals of the EMPHASIZING project?

Alan Banks (AB): This whole project started just over a year ago. I was in discussion with senior researchers at the Welding Institute in the U.K. We were discussing how we can effectively upcycle glass fiber. The problem with glass fiber is that it's probably the most environmentally unfriendly material when it comes to recycling, but it's also really inexpensive to manufacture as virgin material. So, at the moment, there's no real reason that anyone would want to recycle glass fiber, because it just isn't commercially viable to do it.

We were thinking about what we could do to improve that, and were discussing the sizing of the fibers. It occurred to us that maybe we were all missing a trick, that we could size the recycled fiber with something that would give it more of a use in industry, and we thought of graphene — graphene being the strongest material known to man. Although graphene is really expensive, you can use a tiny amount to improve the material properties of whatever you want to use it for. We figured that if we could size the fiber with graphene, then potentially, we would end up with a glass fiber that has significantly more mechanical properties than standard E-glass, X-glass or any of the different glass fibers out there. But because we're making it from recyclate, and we're using a tiny amount of graphene to size it, then we could end up with a material that can be upcycled and that could be relevant to structural components, not just for cosmetic components.

SF: Can you touch on some of the details of the graphene selection as a sizing agent? You talked a bit about it broadly, but can you delve into any detail on some of the properties that it enhances these glass fibers with?

AB: When you put [graphene] in the matrix of carbon fiber (or even glass fiber from a virgin material), then you improve the mechanical properties of the end component by a substantial amount.

Obviously, once you've got the glass fiber, it's random. It's chopped. It has very little commercial value. I think what most people do [to recycle it] at the moment is to put it in concrete as a filler — which is recycled and it's going to be in use for about 100 years — but you don't really get any commercial benefit out of it.

We really want to improve — and give people a reason to use — recycled glass fiber. I'm sure you've seen the pictures of wind blades being buried in fields under mounds of earth. We can't sustain that. We've kind of solved one problem with regard to renewable energy, but we've created another with what we do with the wind blades when they're decommissioned. Currently, they're just being cut up and buried. We're trying to find a way to fix that.

There's the selection of graphene, which is part of the project, but we haven't actually physically done it yet. Currently we've got about 100 kilos of recycled glass fiber from a wind blade. We use a process called "pressolysis" to recycle it. We work with a company called B&M Longworth — they've developed a process which they call thermo-cyclic pressolysis, whereby you use superheated steam. Once you pressurize it, at about 400-500°F, and then decompress the cycle, that strips all of the resin and all of the contaminant from the fiber, leaving the fiber completely clean. It's effectively a cleaning process rather than a purification process where you burn the resin off — because when you burn the resin off, you actually damage the fiber and you end up with a fiber with a lower set of mechanical properties.

So we end up with a clean fiber … and we're hoping that we can size it with graphene. And then we're going to make a structural component for a vehicle, where we're going to test

it back to back with the steel equivalent. That will allow us to confirm that what we've done with the sizing is actually commercially viable.

SF: Can you talk about some of the other opportunities where you see this material possibly being used?

AB: Honestly, it's going to depend on where the mechanical properties turn out. That's phase two of the project, which we're starting now. Once we've managed to size the components with graphene, we'll understand where the mechanical properties lie. We're hoping that we end up with a material that is somewhere between glass and carbon fiber in its mechanical properties, but more toward glass fiber in cost.

I think that was the aim of things like basalt fiber, and other fibers that promised a mechanical property somewhere in the middle, and a price point somewhere towards the lower end. From the experience that I've had looking at those, they always end up the other way around, they have mechanical properties that are close to glass, but costs that are close to carbon fiber. We are hoping that we can do that entirely the other way around.

From an automotive perspective, there's physically no reason why you wouldn't make any component out of it [the graphene-enhanced fiberglass], as long as its mechanical properties are physically able to do it. Fenders, hood panels and tailgate panels — there's no reason why you wouldn't use it for those kinds of things. In a crash situation, they're going to be a lot stronger than traditional glass fiber.

The graphene should add significant strength to the fiber. Then we can explore using graphene-enhanced glass fiber as part of structural components for a vehicle, which is why we've chosen a suspension component from the Ford *Fusion*, to look at how we can compare that to the steel part.

And if we can get really good results on that, then there's no reason why that material couldn't be used for structural suspension parts — side rails, rocker panels and things like that.

BIZ BRIEF

With majority support among shareholders (+99.53%), Solvay (Brussels, Belgium) has announced the official demerging of Syensqo SA/NV, the company's new composite materials segment, from Solvay. Syensqo will be a "company of explorers who will usher in breakthroughs that will advance humanity," Solvay CEO Dr. Ilham Kadri said when separation plans were initially revealed in June 2023. She begins a new chapter of CEO of Syensqo, exploring disruptive material technologies and supporting growing customer needs.

CARBON FIBER

DITF Denkendorf advances sustainable carbon fibers, oxide fibers for CMC and more

The German Institutes of Textile and Fiber Research (DITF, Denkendorf) comprise the largest textile research center in Europe. With more than 250 scientists and technicians, DITF cover the entire value chain — from molecules and fiber chemistry to end-use products. Founded in 1921, DITF state that their most important goal is technology transfer — converting scientific knowledge into market-ready processes, products and services.

DITF are developing multifunctional, cost-efficient and sustainable fiber technologies using the latest digital tools and advances in digitization for six application areas. These activities are supported by six competence centers and four technology centers.

Many DITF projects and technology developments directly involve and impact fiber-reinforced composites. Biopolymer-based composites, 3D-printed bio-based composites, smart self-powering composites and textile-based sensors for composites are just a few that *CW* has reported on. Other more current topics for research in lightweight construction and mobility applications can be found at DITF's webpage, some of which are detailed here.

■ The German Institutes of Textile and Fiber Research (DITF Denkendorf) are developing innovative technologies including the dry spinning (top right) of preceramic fibers being converted into oxide ceramic fibers via thermal processes (middle row) and weaving of those fibers for use in oxide ceramic matrix composites (CMC) shown in the O-CMC burner nozzle and micrograph. The bottom row shows load testing of a sensory composite, polymer fiber research and carbon fiber production at DITF's High-Performance Fiber Center (bottom right). Source (all images) | DITF Denkendorf

Cellulose fibers and more sustainable carbon fiber

Developed by the DITF Competence Center for Biopolymer Materials, the patented HighPerCell technology is an environmentally friendly alternative to the viscose process. It uses ionic liquids, a new type of non-toxic, nonflammable solvent, to produce high-performance cellulose fibers from wood pulp. DITF have also used HighPerCell to produce cellulose/chitin blend fibers with up to 90% chitin from shrimp shells, a waste product from the food industry. DITF are investigating HighPerCell fibers for composites and have also patented a variation, HighPerCellCarbon, to produce precursors for carbon fiber.

In HighPerCellCarbon, precursor cellulose filament fibers are produced using wet spinning with ionic liquids in a closed-loop system where the solvents are completely recycled. The cellulose filament yarns are then converted into carbon fibers using a standard, continuous, two-step oxidation and carbonization process, but the first step is modified to use DITF's low-pressure stabilization process. More on that later. No waste gases or toxic byproducts are produced during the entire process sequence. This development won the Cellulose Fibre Innovation award in 2022.

In August 2023, a pilot line for HighPerCell fiber was opened at DITF's partner Technikum Laubholz (TLH, Göppingen, Germany), a non-university research institute, to produce WDBSD TX wood-based textile fiber from beech wood.

Low-pressure stabilization of carbon fiber

DITF have also developed lignin-based precursors for carbon fiber, but let's start first with its energy-saving concept for carbon fiber production. In cooperation with Centrotherm (Blaubeuren, Germany), DITF have developed a low-pressure stabilization process for carbon fiber precursor that can achieve energy savings up to 50% compared to conventional processing. Stabilization is targeted because that is currently the longest, most energy-intensive part of the thermal treatment to convert precursor into carbon fiber.

As outlined in DITF annual reports, use of partial vacuum during stabilization can reduce process time by up to 30% yet uses up to 50% less energy than conventional processes. Centrotherm's c.OXI Carbon furnace was developed to enable this new stabilization process and is installed at the carbon fiber production line in DITF's High Performance Fibers Center (HPFC), which has six pilot lines for production of carbon and ceramic fibers on a kilogram scale.

The c.OXI Carbon furnace is compact but can easily be adjusted to an industrial scale — Centrotherm cites 1 to 1,000 tons/year. DITF reports that the resulting carbon fibers are highly homogeneous and process control is improved without temperature jumps. The HPFC furnace

has successfully processed industrial 50K polyacrylonitrile (PAN) precursor with high throughput. It can stabilize up to six fiber bundles or three 50K precursors simultaneously. It also has the potential to reduce carbon fiber cost by up to 40%, opening new applications in cost-sensitive markets like construction.

Lignin precursor for carbon fiber

The HPFC is also where lignin precursors for carbon fibers have been developed. "My group started working on this topic around 15 years ago," says Dr. Erik Frank, deputy head of DITF's Competence Center High Performance Fibers and head of its carbon fiber department. "Today, our process is based on dry spinning. So, we use natural, cheap lignin via lignosulfonates and then water as a solvent." The lignosulfonate comes from applying a sulfite digestion process to lignin derived from wood waste. "The costs of this solution, which requires no chemical solvents, are much lower compared to other methods," says Frank. "It costs about 10-50 cents per kilogram, depending on the purity of the material. And we have achieved carbon yields of more than 55% in our process, which is at least comparable to the carbon yield of plant-based fibers. So, we can drop cost and energy demand during the fiber carbonization process."

As explained in a 2023 Textile Technology article, in DITF's water-based dry spinning process, an extruder presses the spinning dope through a spinneret into a heated air shaft, where the resulting continuous fibers dry quickly and uniformly. "This process is much easier than wet spinning because you don't use organic solvents or have to deal with recycling them in production. So, it's also cheaper," Frank says. The high spinning speeds also produce more fibers in a shorter amount of time compared to PAN precursor.

Frank notes that dry spinning is not commonly used for fiber production, because the technology is not so easy to establish. Dr. Bernd Clauss, head of DITF Competence Center High Performance Fibers, explains that DITF originally developed it to produce oxide ceramic fibers (more on this below).

The subsequent steps for the production of carbon fibers — namely, stabilization in hot air and carbonization in a high-temperature furnace — are similar to those used for conventional PAN precursor. However, the lignin fibers can be stabilized more quickly and require relatively low temperatures for carbonization, resulting in 50% energy savings. The resulting fibers are homogeneous, have smooth surfaces and no adhesions.

When asked whether these lignin-based carbon fibers can compete with PAN-based fibers, Frank admits that, while they are promising, DITF is still developing the technology, so the limit of their performance is still unknown. Clauss believes that "it's probably not possible to go to the really extreme high tensile PAN-based fibers, but instead reach intermediate properties [e.g., T300 fiber properties], with a green fiber that has a low CO_2 footprint and which could be cheaper than current similar fibers."

DITF and Clauss and Frank's groups are also doing research into lifecycle analyses (LCA) and establishing best practices because "a more sustainable carbon fiber is our goal," Clauss says.

■ (Left to right) Water-spun lignin precursor fibers, stabilized lignin precursor and carbonized continuous filaments

Development and commercialization of oxide ceramic fiber

DITF have performed research in oxide ceramic fibers since 1990 and are now working with Saint-Gobain Advanced Ceramic Composites (Nemours, France) to commercialize production of its fiber technology on an industrial scale.

Mullite is a mixed crystal of alumina (aluminum oxide, Al_2O_3) and silica (silicon dioxide, SiO_2), while corundum (also called -alumina) is a pure, crystalline form of alumina. The two types of Nextel fiber have different properties, explains Clauss, who works closely with his deputy Dr. Stephanie Pfeifer in the ceramic fiber field. "In terms of mechanical properties, the alumina fiber, which is Nextel 610, is superior with the highest tensile strength and the highest modulus," he notes. "But in terms of thermal stability, the mullite/corundum fiber, which is Nextel 720, is better. For really high-temperature performance, close to 1,100°C or even a little higher, you must go to mullite because the alumina fiber won't survive at this temperature for a long time."

Maximum temperature for these fibers depends on "how much time they operate at that temperature," says Clauss. For long service life in CMC turbine components for example, he notes that SiC fiber is what you have to use. "And this is what's already being done and further planned in turbines: SiC composites in the hot section while the oxides are used at the lower temperature regions of these sections." Note, oxide fibers don't need a final coating like SiC fibers do. "For oxide CMC, we put non-coated fibers in a matrix and get a porous matrix at the end, which gives a fiber-dominated behavior and the damage tolerance you need for CMC (weak matrix concept)," says Clauss. "You only need a coating if you want to have a dense matrix like with SiC. And then the coating enables what's called the weak interface concept. But we don't need it for oxide CMC."

Although DITF do not currently work with SiC fibers, they have developed both alumina and mullite oxide fibers, as well as an industrially scalable process for continuous fiber production. This has involved *(continued on page 18)*

(continued from page 17)

development of spinning dopes and spinning process, characterization of the fiber structure formation process, optimization of fiber properties, handling and storage of green multifilament fibers (developing a spin finish), thermal processing of the green fibers into ceramic fibers, recycling of process waste and increasing production speed. As explained in a 2021 ceramic-applications.com article, DITF's OxCeFi A99 fiber is similar to Nextel 610, being 99% corundum (-alumina) but does not use iron oxide for controlled structure formation. However, DITF claims there is no counterpart to their OxCeFi M75 fiber, which is 96% mullite, because Nextel 720 is typically a mixture of corundum and mullite. OxCeFi M75 reportedly offers similar creep resistance but optimized high temperature stability.

Since 2018, DITF have operated a pilot plant in Denkendorf representing the complete manufacturing chain. In 2021, they completed the agreement to work with Saint-Gobain to commercialize OxCeFi A99 and OxCeFi M75 fibers, with industrial production scheduled to start in 2025.

DITF also continues to research new material compositions. They are aiming at even better properties at higher temperatures using multiphase systems and elements such as Zirconium (Zr) and Yttrium (Y). Pilot production of Zr-toughened alumina (OxCeFi ZTA) and Zr-toughened mullite (OxCeFi ZTM) fibers are already well advanced. DITF hope to avoid grain growth and creep properties through these new fiber types, and to increase their temperature resistance.

DITF have not stopped at the fiber but proceeded through subsequent steps to the end product. For example, weaving the shear-sensitive ceramic fibers presented some issues. After some technical adjustments on a 3D rapier weaving machine using Jacquard technology, DITF showed it was possible to process both OxCeFi A99 and OxCeFi M75 fibers in large quantities. The newer fiber types have also been successfully woven. Fabrics were then processed into CMC demonstrator parts in cooperation with Walter E.C. Pritzkow Spezialkeramik (Filderstadt, Germany). With bending strength values of more than 400 megapascals, the CMC properties showed that Denkendorf fibers can compete with current Nextel fibers. DITF will also continue to focus on producing higher filament counts to reduce fiber costs.

This article is an edited excerpt. Find the complete article online at short.compositesworld.com/DITF-developments

CARBON FIBER

Holy Technologies platform enhances carbon fiber component recyclability

Deep-tech company Holy Technologies (Hamburg, Germany) announces a significant breakthrough that presents a viable solution to the longstanding challenge of recycling carbon fiber components.

Independent tests conducted at the Technical University of Hamburg (Germany) have demonstrated the robustness of Holy Technologies' Infinite Component Platform that enables composite components designed for recycling. Results indicate that through this platform, components recycled retain 95-96% of their original mechanical properties, with only 4-5% degradation. Moreover, when transitioning through subsequent cycles, such as the second to the third life of the product, the fiber maintained 99% of its properties, reflecting only a 1% loss in mechanical properties. Holy used novel recyclable resin Recyclamine by Aditya Birla (Mumbai, India), and focuses its IP on achieving the highest possible degree of recyclability for the fiber rovings.

A critical aspect of this development is the ability to properly recycle rather than downcycle the carbon fiber components, Holy reports. This distinction is vital, as it enables the recycled components to be used for the same high-end applications as their original counterparts, a feat that stands in contrast to most existing recycling methodologies."We see a viable path to give carbon fibers up to seven lives as long as our technology is utilized during design, manufacturing and recycling," Bosse Rothe, CEO of Holy Technologies, says.

Holy Technologies is a startup company seeking to decarbonize lightweight manufacturing by designing scalable, sustainable production systems. It has developed a software-hardware production system for industrial-scale composites manufacturing that uses a combination of machine learning and additive manufacturing.

Source | Holy Technologies

What makes Holy's approach distinctive is the elimination of fiber cutting during manufacturing in combination with an intelligent fiber deposition engine that considers parameters from the entire production cycle, from design and manufacturing to recycling. Holy develops software that calculates the ideal fiber paths to enable components out of one single fiber. By integrating factors like geometry, fiber properties, manufacturing settings, load conditions and recyclability constraints, the software determines the most efficient route for fibers. The ambition is to achieve an industrial-scale production system that cuts the production costs of composites by up to 50%.

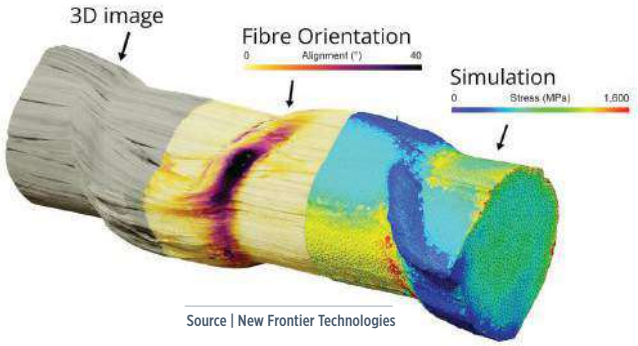
New Frontier Technologies launches digital twinning, high-fidelity simulation capability

New Frontier Technologies Pty Ltd. (Canberra, Australia), a startup company that provides bespoke design, manufacture and 3D evaluation of carbon fiber composites and other advanced materials, has developed a capability for digital twinning of composites for high-resolution quality characterization and high-fidelity performance simulation.

As the use of virtual engineering environments and development of digital certification increases in sectors that rely on composite materials and structures, the demand for high-resolution 3D datasets for quality characterization and performance evaluation will also increase, the company reports. New Frontier Technologies' 3D digital twinning capability is based on X-ray computed tomography (CT) to image and analyze — at micron resolution — critical quality characteristics of composites such as void size and distribution, and fiber orientation. A finite element mesh that captures these characteristics is then generated for high-fidelity simulation. This enables performance evaluation of the as-manufactured component rather than an idealized model.

"The power of this capability is that we can analyze and simulate the performance of what has actually been *made*, rather than what was *hoped for*," says Paul Compston, director and CEO of New Frontier. "It is an enabler for rapid design iterations and performance evaluation, and for digital certification processes that are increasingly important for the aerospace sector."

Compston continues: "Our current partners and clients are using our digital twinning capability where it is essential to confirm that the manufactured composite components



Source | New Frontier Technologies

will perform as required. In the space sector for example, void content thresholds must be met in satellite structures to avoid out-gassing problems, and for precision instrumentation, the fiber orientation determines thermal performance and hence dimensional stability. This capability can provide, in 3D, the critical information required to assure quality and performance of the composite [material] in such high-value applications."

Application of this technology is also ideal during product development phases, where information for rapid design iterations and process parameter optimization is required. Areas with high-geometrical complexity, or where high stress concentrations and complex load cases are expected, can be assessed in intimate detail. The effect of critical features can then be simulated with high-fidelity, which minimizes the need for time-consuming, expensive inspection and testing.

3D imaging can be undertaken on components up to 1 meter in length and 300 millimeters in width or diameter. For larger dimensions, a multiscale modeling approach can be taken, where high-resolution results from representative areas are applied to the whole structure.

AEROSPACE

GKN enhances aeroengine agreement with GE Aerospace

Tier 1 aerostructures supplier GKN Aerospace (Redditch, U.K.) has strengthened its partnership with GE Aerospace (Cincinnati, Ohio, U.S.) through an agreement that includes new technology insertion, fan case production and assembly, and repair of high-volume, complex engines structures. GKN already provides components for several engine series, including the GEnx high-thrust engine program.

Technology insertion programs for the GEnx will focus on alternative material solutions, providing a more sustainable manufacturing footprint for several products currently flying. GKN Aerospace will provide component design expertise as well as its latest technologies, to drive the program toward its carbon emissions reduction targets and cost reduction. Upgraded components are expected to go through development, validation and insertion from 2024 to 2030.

Under the agreement, GKN Aerospace will now deliver 100% of GEnx, CF6 and GE90 fan cases, as well as 50% of GE9X fan case assembly for the duration of the program. According to *Aviation Week*, GKN currently supplies GEnx, GE90, GE9X and CF6 components directly to GE Aerospace.


Source | GKN Aerospace

As part of the partnership, GKN also joins GE's repair network, supporting the GEnx with specialized repair content with its expertise in structural design-and-make of advanced fabrications to repair high-volume, complex structures across its global repair network.

Forvia wins innovation awards for biocomposites, CFRP hydrogen tank

Forvia (Nanterre, France) recently received three accolades at the European Association of Automotive Suppliers' CLEPA Innovation Awards 2023, the eighth edition of the international competition that recognizes organizations, SMEs and startups for automotive innovations that support the green and digital transitions in Europe. Two of the three awards use and/or impact composites.

Biocomposite materials for reduced emissions

One award recognizes Forvia's NAFILean family of biocomposite materials. An addition to this family, NAFILean-R, combines 20% natural hemp fibers with a low-CO_2 polypropylene (PP) matrix that is 40% recycled. The result is a material that not only reduces weight but also minimizes CO_2 emissions by up to 87% compared to industry benchmarks. NAFILean-R is powered and brought to the market by Materi'act, a subsidiary of the Forvia Group specializing in sustainable materials.

In 2022, Forvia became a forerunner in terms of decarbonization by having its net-zero roadmap approved by SBTi. Under this roadmap, Forvia commits to reach net-zero CO_2 emissions across the value chain (scopes 1, 2 and 3) by 2045, with two intermediate steps: net-zero emissions on scopes 1 and 2 by 2025 and reduction of scopes 3 emissions by 45% by 2030. NAFILean, developed over the past decade, serves the company's net-zero ambition. It has already been used for instrument panels, center consoles and door panels, and chosen by major OEMs such as Renault, Stellantis and Nissan.

NAFILean, made from natural fibers, such as hemp and PP, features 20% biocontent and is 100% recyclable. The evolving biocomposite material family is designed for technical plastic parts, offers excellent stiffness, crash performance and resistance to aging. The choice of hemp fibers, known for their environmental credentials, underlines Forvia's commitment to reducing the carbon footprint of the automotive industry.

Tanks that address heavy-duty hydrogen mobility needs

Forvia also presented its XL Tank, a Type IV tank that features a plastic liner overwrapped with carbon fiber and epoxy resin. It can store more than 20 kilograms of gaseous hydrogen under 700-bar pressure. The tank is also capable of reaching 1,000+ kilometer autonomy, and recharges from 0-100% autonomy in less than 15 minutes, by refueling in a hydrogen station.

Source | Forvia

The XL Tank's design allows for easy vehicle integration, making it a valuable solution for installing on new chassis or retrofitting existing vehicle fleets to zero emissions. Several customers, including e-Neo, have already put their trust in the XL-Tank. Product deliveries will start in 2024.

"These awards reflect Forvia's relentless commitment to driving innovation and sustainability in the automotive industry, whether through groundbreaking technologies for zero-emission mobility and services as well as sustainable materials, at the service of our customers and end-users," Christophe Aufrère, CTO at Forvia, says. "This recognition fuels our determination to continue leading the way on safer and more sustainable mobility."

What is Materi'act?

Materi'act develops, transforms and commercializes materials with a low CO_2 footprint through the formulation and processing of recycled, bio-sourced and carbon-capturing materials. Its sustainable products include recycled and bio-based compounds, bio-based foils, low CO_2 carbon fibers and green steel that find uses in the automotive industry and beyond, like aerospace, construction and sporting goods.

Forvia reports that its bio-based carbon fibers provide customers with high stiffness, tensile strength, chemical resistance, high-temperature tolerance and low thermal expansion. They will initially be used for the production of hydrogen tanks.

Its recycled and bio-based compounds are suited for injection molding and can be tailored to meet various performance requirements.

BIZ BRIEF

In a stride toward eco-friendly maritime innovation, Greenboats (Bremen, Germany) announces the launch of the MB9 sailing boat. Designed by the veteran naval architect Matthias Bröker of design engineering company Judel/Vrolijk (Bremerhaven, Germany), the MB9 represents a fusion of top-tier performance and sustainability. Having just "hit the water," the vessel is poised for final outfitting before its official debut in the 2024 sailing season.

The sailing boat is almost entirely made from natural materials like flax, balsa wood and bio-epoxy, weighing in at just over three tons.

Skyrora, Spirit AeroSystems collaborate to enhance future U.K. launch capabilities

Private space company Skyrora Ltd. (Edinburgh, U.K.) and Spirit AeroSystems (Belfast, Northern Ireland) have announced a collaboration on orbital launch capability. The partnership will enable Skyrora to transition its orbital launch vehicles from development to full-scale production using Spirit's highly adaptive manufacturing and testing solutions in metallics and composites, in addition to localizing its supply chain.

Skyrora is developing an agile, end-to-end, launch service to provide access to space for small satellites globally. Having conducted a test launch of the suborbital, single-stage *Skylark L* vehicle in October 2022 as part of the company's incremental learning approach to launch, Skyrora says it is on track to become the first U.K. company to vertically launch satellites from the U.K., expecting to conduct up to 16 launches per year once operating at scale.

SkyLark L is 11.65 meters in length and 0.7 meters in diameter, with a payload mass of 50 kilograms. Like Skyrora's *Skyrora XL* 22.7-meter three-stage, light class launch vehicle, the craft uses fiberglass, carbon and aramid fibers reinforced with polymers such as epoxy, vinyl ester and polyester resins.

"By collaborating with innovative partners like Spirit, Skyrora will be able to access manufacturing and testing capacity right here in the U.K.," Volodymyr Levykin, CEO and founder of Skyrora, says. "Historically, space has not been an environmentally friendly industry, but we are committed to being a responsible player that continues to foster talent and skills nationally as the ambitious New Space economy goes from strength to strength."

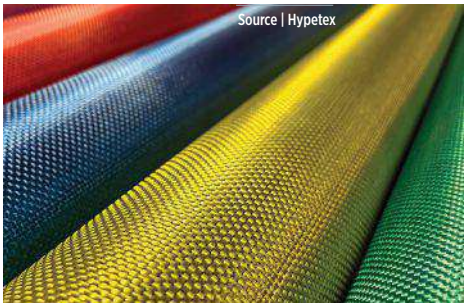
Source | Skyrora

Spirit's presence in U.K. space is growing. Its broad offering of manufacturing and testing solutions, at both its Scotland and Northern Ireland facilities, brings significant industrial capacity to Skyrora's launch proposition. Leveraging Spirit's aerostructures expertise, the companies will explore opportunities to transition Skyrora's orbital launch vehicles from development to full-scale production.

Collaborative goals also include the research of space technologies, particularly in additive manufacturing. Skyrora will provide Spirit with access to Skyprint 2, claimed to be the largest in-house hybrid 3D printer of its kind in Europe. Located in Skyrora's manufacturing facility just outside Glasgow, research enabled by Skyprint 2 has the potential to unlock a localized supply chain to reduce costs and lead times for Spirit, bolster industrial cooperation and promote growth within the U.K. space sector.

Hypetex extends colored composites to marine industry

British composites company Hypetex (London, U.K.) announces that it is expanding into the marine sector. Born out of Formula 1 technology, Hypetex offers manufacturers sustainable advanced materials with technical and efficiency benefits. Its materials provide colorful aesthetics, combining visual appeal with weight, technical and cost-saving advantages for lightweight, high-performance products.


Source | Hypetex

The use of carbon and natural fiber in the marine industry is growing rapidly, used in hulls, superstructures, accessories and spars, which is where Hypetex comes in. Using its materials, boatbuilders will be able to achieve desired aesthetics while maintaining optimal performance. The materials also offer high stress tolerance, ensuring greater durability and longevity for marine products and benefit from lower maintenance costs.

Hypetex has already proven successful in the marine industry, having provided its materials for the Imoca 60 Race Yacht by Jason Carrington, as well as the automotive sector, recently collaborating on the Ford *Mustang*, and producing an all-body colored carbon fiber BAC Mono R supercar. Hypetex also works within the sporting, orthopaedic and luxury goods sectors.

Assisting Hypetex in joining the marine industry is Resintex Technology (Frosinone, Italy), a distributor of advanced composite materials specializing in the marine sector. Resintex prioritizes material availability, swift deliveries and comprehensive technical communication.

"The use of advanced composites in the marine market continues to grow and Hypetex's solutions offer exceptional and durable finishes, without taking away the performance of the vessel," Peter Tyler, marine business advisor Hypetex, says. "Hypetex joining the marine industry demonstrates the continuing growth of the company that already operates across a wide variety of sectors."

CARBON FIBER

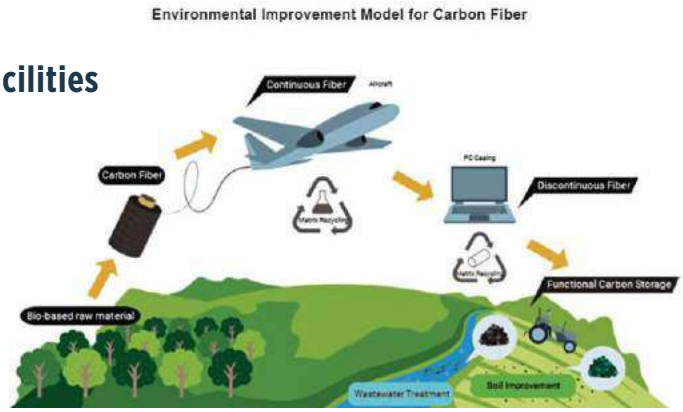
Toray obtains ISCC certification for European carbon fiber production facilities

Toray Industries Inc. (Tokyo, Japan) has announced that its French subsidiary, Toray Carbon Fibers Europe S.A., has obtained ISCC Plus certification for its Lacq and Abidos production plants in South West France. This certification enables Toray Carbon Fibers Europe to allocate and use biomass or recycled materials through the mass balance approach (see more on this below) to produce and supply carbon fiber. Thus, the subsidiary now has the ability to reduce the lifecycle inventory (LCI) of its carbon fiber, prepreg and other offerings and help its customers to enhance product lifecycle assessments (LCA) while contributing to building a circular economy.

The ISCC Plus International Sustainability & Carbon Certification (ISCC), a voluntary certification program, guarantees that the raw materials used are sourced from biomass or recycled materials. It also ensures that there is complete traceability at all stages of the manufacturing process of a product. The mass balance approach tracks the amount and sustainability characteristics of circular and bio-based materials used in the value chain and it is based on verifiable record. This project is open to several sectors such as the food, feed, chemicals, plastics, packaging and textile industries.

Toray Carbon Fibers Europe will start manufacturing carbon fiber derived from biomass and recycled raw materials by the end of 2023. In addition, Toray's Ehime Plant in Japan aims to obtain ISCC Plus certification by March 2024 and begin producing fiber by close of that year. In the U.S., Toray Composite Materials America Inc.'s carbon fiber facility in Decatur, Alabama, also plans to obtain this certification in 2024. With these three locations obtaining certification, the Toray Group intends to manufacture carbon fiber using biomass or recycled raw materials at plants in Japan, the U.S. and Europe, ensuring stable supplies to customers around the globe.

Toray has already received requests from customers similarly committed to carbon neutrality. From the end of 2023, Toray will offer this carbon fiber for industrial applications such as automobiles and handheld devices where demand for materials to create sustainable products is particularly high. At a later date, other applications, such as aviation and sports, will also be targeted.



Source | Toray Industries

This effort aligns with the Toray Group's carbon fiber composites business roadmap to achieve carbon neutrality by 2050. Under Project AP-G 2025, its medium-term management program, Toray is actively contributing to the development of a more sustainable economy by quantifying the LCA improvements of customer products, reducing the LCIs of carbon fiber, prepreg and other offerings, and using and recycling bio-based materials as part of its new materials ecosystem.

Toray aims to build a new materials ecosystem that harnesses natural raw materials and returns them to nature in an eco-friendly state. For carbon fiber, the ecosystem will be built using biomass and recycled raw materials to manufacture carbon fiber. This fiber will be made into a composite material and, finally, an end product. At the end of the product's lifecycle, continuous carbon fiber will be repurposed for the use as discontinuous fiber in other products. The last stage of the carbon fiber's lifecycle will be its recycling for water treatment or soil improvement.

BIZ BRIEF

Hexagon Purus (Oslo, Norway) continues to make headway in the transportation sector with new purchase order announcements for its Type IV hydrogen storage systems by Ford Trucks (Dearborn, Mich., U.S.).

The company will be delivering a complete hydrogen fuel storage system for the development of a fuel cell electric-powered vehicle (FCEV) as part of the Horizon Europe project Zero Emission Freight EcoSystem (ZEFES). As a partner in ZEFES, a pan-European project specifically targeting decarbonization of long-haul heavy-duty trucking in Europe, Ford Trucks will develop and deliver a fuel cell electric heavy-duty prototype *F-Max* truck that will operate as part of a larger fleet of zero-emission trucks collecting data from real-world operations.

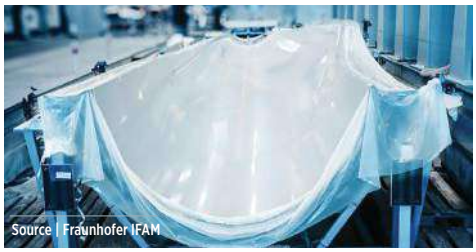
The *F-Max* FCEV will be Ford Trucks' first fuel cell-powered vehicle, developed and manufactured in Turkey, and will begin European Ten-T corridor demonstrations in 2025 as part of ZEFES project goals.

ZEFES will deploy a total of nine different long-haul truck configurations split into six battery electric- and three fuel-cell electric trucks. The nine trucks will operate for 15 months.

ENERGY

OptiBlade project increases rotor wind blade production efficiency

Within the joint project OptiBlade, researchers at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM (Fraunhofer IFAM, Germany), in collaboration with Olin Blue Cube Germany and Infiana Germany, have pioneered a release agent-free process and material system that have the potential to transform rotor blade production for wind turbines. This development is poised to propel the expansion of wind turbines in alignment with the Energy Concept 2050.


Source | Fraunhofer IFAM

As part of this project, Fraunhofer IFAM initiated the operation of a state-of-the-art low-pressure plasma plant tailored for web material and devised plasma processes capable of applying an ultrathin plasma polymeric release layer to polymer film half-tubes up to 2.4 meters wide. The resulting flexible and stretch-formable Peel^{Plas} release film, an evolution of the Fraunhofer IFAM Flex^{Plas} release film, expands to a width of up to 4.8 meters when unfolded. Moreover, this release film can be seamlessly welded for even wider molds used in fiber-reinforced plastic (FRP) rotor blade production without any complications.

Furthermore, through a specialized process, a 4.2-meter Peel^{Plas} release film half-tube was applied onto an 18-meter segment mold at Fraunhofer IWES, in cooperation with Olin Blue Cube Germany, creating a 40-meter-long FRP rotor blade demonstrator. The plasma-coated Peel^{Plas} release film facilitated transfer-free demolding of the large FRP component, eliminating the need for traditional release agents. Subsequently, the epoxy resin matrix of the component was coated with a repair coating for rotor blades without additional pre-treatment, showcasing optimal adhesion even after exposure to a condensation water test for 1,000 hours.

The Plasma Technology and Surfaces experts and Automation and Production Technology experts at Fraunhofer IFAM developed the plasma-coated flexible Peel^{Plas} release film based on a thermoplastic elastomer. This release film, tailored to specific industry and customer requirements, substitutes conventional release agents, ensuring carryover-free and reliable component demolding, thereby ensuring consistently high component quality for contamination-free, large FRP components.

The processes developed by Fraunhofer IFAM under OptiBlade using the Peel^{Plas} release film are reported to significantly enhance value addition throughout the process chain. Notably, these innovations optimize rotor blade surface quality, eliminate labor- and time-intensive manual tasks in tool molds and reduce mold loading time, extending mold service life.

The successful culmination of the OptiBlade project's first phase has spurred plans for a new plasma-coated multilayer film under the "Sustainable and efficient rotor blade production with emission-reduced processes for the formation of surfaces" (NEOFOIL) cooperation project as part of the 7th Energy Research Program of the German Federal Ministry for Economic Affairs and Climate Action (BMWK). This new film aims to serve as a semi-permanent release film affixed to molds, enabling multiple demoldings of FRP components.

Moreover, the knowledge and technologies derived from OptiBlade are poised for transfer to diverse industries such as aircraft, spacecraft, rail vehicle, commercial vehicle, automotive, shipbuilding and sports equipment manufacturing, promising increased production efficiency.


Source | Element Materials Technology

Element, Magma Global renew partnership to extend m-pipe capabilities

Element Materials Technology (London, U.K.) announces the renewal of its strategic partnership with Magma Global (Portsmouth, U.K.), a TechnipFMC company that develops composite pipes to simplify subsea oil and gas architecture. The collaboration is specifically focused on advancing thermoplastic composite technologies for the energy sector through rigorous testing and validation.

In this renewed partnership, the two companies will harness Element's state-of-the-art facilities in Hitchin, U.K., to evaluate and extend the capabilities of Magma's m-pipe systems. The lightweight, high-strength, carbon fiber-reinforced polyetheretherketone (PEEK) m-pipe provides corrosion resistance, pressure ratings and rapid deployment that is said to be unmatched by traditional steel or flexible pipe alternatives. Importantly, it is engineered to withstand prolonged exposure to high temperatures, harsh chemicals and moisture, ensuring reliable performance in offshore and subsea environments.

"Their [Element's] world-class laboratory will prove invaluable as we work to ensure the ongoing success and evolution of our m-pipe product line to meet critical needs in offshore, subsea and other demanding energy applications," Julia Campbell, senior project manager at Magma Global, notes.

Luke Shield, general manager for Energy UK South at Element Hitchin, notes that the collaboration will drive innovations that enhance safety, performance and sustainability. In particular, the testing data generated through the partnership will provide significant insights to assist Magma in optimizing its thermoplastic pipe systems and qualifying them for new operating environments.

Speak at CW's Sustainability Tech Days event on April 17

CompositesWorld has announced that the latest installment in its Tech Days online event series will be focused on sustainability practices in the composites industry. The event is scheduled to take place Thursday, April 17, 2024, from 11:00 a.m. to 3:30 p.m. ET.

CW's Tech Days are designed to offer informational presentations from industry experts spanning the entire composites supply chain. The Sustainability Tech Day will explore the technologies, materials and strategies that are helping composites manufacturers become more sustainable. Key topics covered in the presentations will include:

- Waste reduction
- Energy efficiency
- Biomaterials
- Recycling

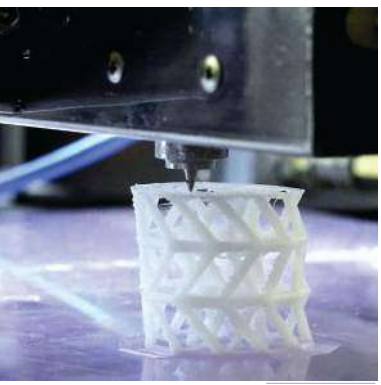
Given the increasing demand, especially from OEMs, for sustainable business practices within the composites industry, there is a need for supply chains to adopt and implement environmentally friendly strategies to help the world meet decarbonization goals. This event will equip composites fabricators with the knowledge they need to meet the sustainability requirements they will face in the months and years ahead.

Source | Fraunhofer IPT (top left), Anmet (top right), Getty Images (bottom left and right)

Call for abstracts

Material and equipment suppliers, along with industry experts interested in presenting at the Sustainability Tech Days event on April 17, are invited to submit abstracts to press@compositesworld.com. Please reference "*CW* Sustainability Tech Days" in the subject line. Submitted abstracts will be considered for inclusion in the event agenda.

Keep an eye on compositesworld.com/events for further updates about this event.



Source | BellaSano

SCABAEGO project develops bioactive composite that supports healing of broken bones

The Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM, Bremen, Germany) has provided a solution for the healing of broken bones through the SCABAEGO (Scaffold Bioactive Glass-Enhanced Osteogenesis) joint research project. The project's aim is to test the working hypothesis that using bioactive materials in operations supports the healing process and reduces the risk of infection. The institute's partners for the project include the Department of Trauma and Reconstructive Surgery at the Heidelberg University Hospital (Germany) as well as BellaSeno (Leipzig, Germany), a company specializing in medical engineering.

Fraunhofer IFAM researchers have developed a composite material from biodegradable polymer polycaprolactone (PCL) and bioactive glass. The composite material is then used to 3D print customized main and supporting structures — called scaffolds — for bone fracture sites. Prior to this, the structure of the damaged bone is mapped using computer tomography (CT). The custom-fit structure replaces the missing part of the bone. It is then filled with bone marrow taken from the iliac crest or from larger long bones. This promotes that the biological bone replacement material (autologous bone craft, ABG) is stably contained and the fracture site heals safely.

The medical product provides even more advantages. "The bioactive glass in the scaffold raises the pH of its surroundings to alkaline," explains Dr. Kai Borcherding, head of the Medical Technology and Life Sciences business unit at Fraunhofer IFAM. "The next thing we want to investigate is the expected result of this, which is inhibiting bacteria growth." The researchers expect this to reduce the risk of postoperative infection.

The bioactive glass also supports the growth of new bone at the fracture site. Because it is in contact with bodily fluids, the glass turns into hydroxylapatite, which is a chemical compound derived primarily from calcium phosphate and a substance very similar to bone.

Bioactive glass is already used for treating bone defects. What's new is combining it with PCL on an industrial scale. Fraunhofer researchers have succeeded in binding glass and PCL to create a composite material that can be used directly in additive manufacturing. The main result is that customized 3D scaffolds can be produced.

A CT scan of the damaged bone is taken to produce a 3D virtual image. Project partner BellaSeno then prints the scaffold from this material using a 3D printer "so that we can create each scaffold individually to fit the fracture site for each patient," says Dr. Mohit Chhaya, managing director of BellaSeno and project coordinator.

Voith Composites certifies towpreg-wound Carbon4Tank for on-road use

For hydrogen (H_2) tanks to be released on the road in Europe, they must receive type approval under United Nations Economic Commission for Europe (UNECE R 134) regulations. The Type IV 700-bar H_2 storage vessel Carbon4Tank with a 350-liter capacity from Voith Composites (Garching bei München, Germany) has recently earned this approval for road use, and is ready to be applied to heavy-duty trucks and other commercial vehicles. Voith says this is an important step toward the introduction of an H_2 economy and the decarbonization of the transportation sector.

During the development of Carbon4Tank, innovative materials and processes were used and set up from the beginning to enable automotive qualities and high volumes in production. Within the approval tests, the tank had to meet stringent performance requirements to receive certification for on-road service, including testing for burst pressure, pressure cycle life, expected on-road performance, fire safety, component isolation and a combination of these tests.

According to Voith Composites CEO Anna Pointner, "This certification is an important milestone following an intensive development period. It recognizes the hard work and expertise of our team in producing composites at scale for the automotive industry. Our emphasis on high-quality data is critical when ensuring absolute safety and consistency in manufacturing, which this certification demands."

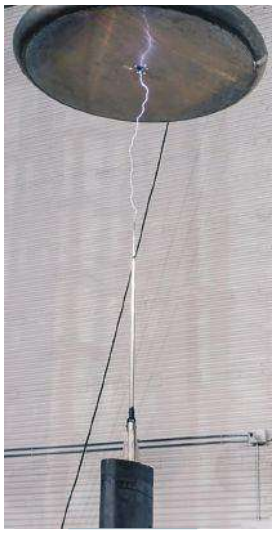
Source | Voith Composites

With UNECE R 134 certification, the towpreg-wound H_2 tanks from Voith Composites have underlined the maturity of the product and production and are now ready for serial production. The first well-known truck OEMs are already working to integrate these tanks.

Future Fibres' LiMit Collar protects composite rigging against lightning

Composite rigging specialist Future Fibres (Valencia, Spain) has been named one of the winners of Mestrade's DAME Design Awards 2023 under the "Security and Safety Aboard" category. Chosen as an example of a standout example of holistic design effort within the marine equipment sector, the company's lightning mitigation system for carbon composite rigging (LiMit Collar) has proven a valid solution to protect composite rigging from the effects of lightning.

The LiMit Collar is a range of multistrand composite rigging products that are the result of a multiyear, €375K R&D program to better understand the issue of lightning strikes on masts. This included lightning strike testing under the most demanding aerospace standards with varying environmental conditions, as well as subsequent mechanical tests to understand the properties of the cables after a strike. Studies involved 350-plus strikes to develop rigging damage characterization and protection development, as well as spar interaction, current distribution and lightning protection systems.

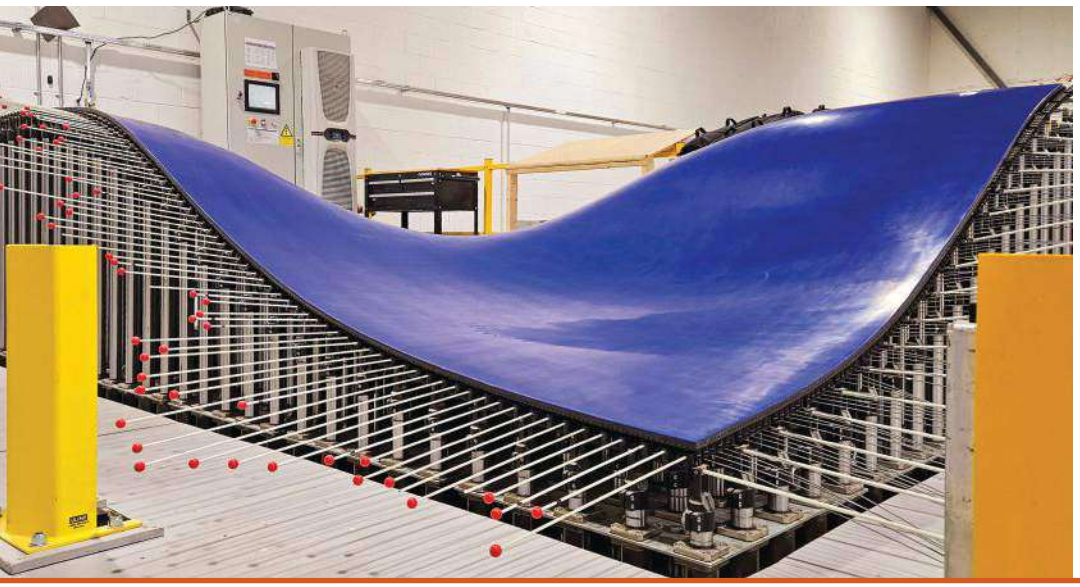


Source | Future Fibres

"Even though carbon fiber is not a perfect conductive material, it can still transmit electric current which means that in lightning events, the current can reach and spread across both metallic and composite structures," Juanjo de la Cuesta, R&D manager at Future Fibres, explains. "Another reason why large composite rigs and stays are subject to lightning damage is because, apart from their relatively good conductivity, they have a reasonably large diameter, and as a result, significantly lower inductance compared to conventional metallic down conductors. Therefore, it is likely for the current to partially arc toward these structures and flow through the path with the overall lowest impedance. This, added to the fact that composites are normally sensitive to high temperatures like the ones that can take place during lightning arcing, for instance, highlights the necessity to include the lightning events in the design requirements of those structures that may be subjected to them."

Composite rigging is typically composed of a carbon fiber core, epoxy resin cone ends and titanium end fittings. The LiMit Collars is designed as a multilayered and multi-material system — it has both conductive and insulating materials that prevents a lightning current from arcing from the carbon fiber core to the metallic terminals. Rather, the solution provides an alternative path for the current by absorbing the strike. Future Fibres says that when installed at each conical end fitting with a metallic interface connection of rigging, LiMit Collars have been capable of protecting sailing boats with carbon fiber spars up to 90 meters high, said to be the largest ever built. Moreover, use of LiMit Collars could translate to lower downtime (reduced need for inspections or repairs) and overall enhanced safety.

As a result of the program, LiMit Collar is offered on all rigs for boats above 100 feet by default. Future Fibres is looking forward to bringing these findings to industry.



BeSpline uses Adapa adaptable mold systems to produce 3D curved composites with carbon, glass and/or natural fibers, as well as a variety of resins and bio-resins. Source | beSpline

PLANT TOUR:
BeSpline/Addcomp

Sherbrooke, QC, Canada

Composites automation specialist increases access to next-gen technologies, including novel AFP systems and unique 3D parts using adaptive molds.

By Ginger Gardiner / Senior Technical Editor

» Many of the composites facilities *CW* has toured are notable for their sheer scale. Most are also involved with advancing new composites technologies and/or markets. The latter is indeed what distinguishes beSpline and Addcomp, two companies housed in the same location about an hour east of Montreal in Sherbrooke, Canada. Their facility — a new, multi-tenant industrial building with plenty of room for growth — is ample in size, but not the focus. Instead, what stands out is this group's push for innovative composites technologies and making these available to companies and markets outside the norm.

"Tier 1 aerospace companies have large budgets to buy bespoke composites automation and advanced technology," says Yoann Bonnefon, CEO of beSpline and Addcomp. "Our goal is to lower the barrier for SMEs to implement such technologies. We have shown through multiple studies with U.S. clients that we can provide not only cost and time savings, but also increase the quality and performance of their products and reduce waste."

Composites, automation to technology portal

The history of beSpline and Addcomp begins with Bonnefon's background in composites. Born in France, he completed his Master's thesis in mechanical engineering with Airbus Filton in the U.K. and then worked as a stress engineer for Atkins Aerospace (Epsom, U.K.) on the all-composite Airbus A400M wing and

Source | ©MapQuest/ Getty Images

spar, followed by optimization of A350 wingskins and stringers. Subsequent tenures included work on the 787 movable trailing edge for Boeing Australia, crash simulation/design of train structures for Bombardier Transportation France, 4 years on Bombardier's Learjet 85 program and 5 years at Composites BHS, where Bonnefon worked to develop new projects and became manager of innovation. "My background has been really helpful because I've seen so many aspects of composites," he notes. "I began to really feel passionately about the need to make new technologies more widespread."

In 2018, Bonnefon and a partner started the IND Group in Sherbrooke to provide design and project management for automation. "With one of my partners having a background in robotics and mine in composites, that's where we started. And then the business grew to a broader set of applications, so Effman became the name of our composites services division," says Bonnefon. "After 2 years, the IND Group started to make systems in a more series fashion, but for composites this isn't really possible. Every application is somewhat unique due to the different products and markets that companies are targeting. And then I saw Addcomposites [Espoo, Finland] and worked with them to form Addcomp as the North American integrator."

In 2019, *CW* reported on Addcomposites as a startup trying to democratize automated fiber placement (AFP) and tape layup (ATL) by developing a plug-n-play solution called AFP-XS. This compact and lightweight tool head (12 kilograms without material) mounts onto most robotic arms (e.g., KUKA, FANUC, ABB, Kawasaki, Yaskawa), comes with its own proprietary path planning and digital twin software, AddPath, and is modular, offering automated layup at a fraction of the cost for traditional large gantry and robot AFP/ATL systems. Users can lease a system for ≈€3,500 per month or buy an AFP-XS head ouright.

Bonnefon explains that if Addcomposites sells a simple AFP-XS head, then it will just ship that directly to North America. "But if the customer wants a full AFP cell, then Addcomp works with them to design, optimize and install a complete integrated system. We wanted our brand name for this work to be close enough to the technology developer, but also to differentiate us as an integrator." A first system was installed at the Quebec Composites Development Centre (Saint Jérôme, QC, Canada) in 2020 and Addcomp now has four installations in process.

"And then in 2020, I came across Adapa's [Aalborg, Denmark] adaptive molding technology at CAMX," says Bonnefon. "We started beSpline, acquired the first equipment and started operations in December 2021. We are the first company to use this technology to make 3D composite panels in North America." BeSpline is supplying Shaped Foam Kits to the marine industry and a variety of shaped composites into architecture/construction and special projects. "We use different types of resins, reinforcements and cores and have developed different recipes and techniques that provide 3D shapes while saving time, cost and waste because we eliminate building a mold," adds Bonnefon.

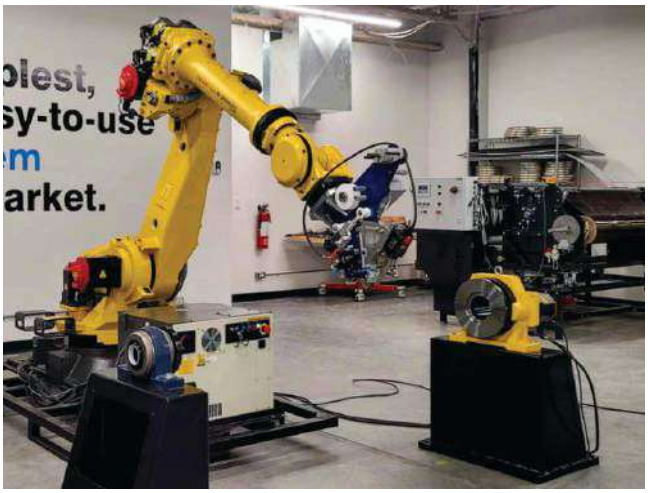


FIG. 1 Integrating low-cost AFP for North America

Addcomp works with North American customers of Addcomposites to design, optimize and install complete integrated cells for its modular, multi-material-capable AFP-XS systems. Source | Addcomp

Shaped Foam Kits

One of the first products beSpline developed was its Shaped Foam »

Kits. "We connected with Curve Works [Alphen aan den Rijn, Netherlands], the first company in Europe to use the Adapa reconfigurable molds for composites manufacturing," says Bonnefon. "And we licensed the technology, drawing on the knowledge, software and techniques Curve Works developed for its 3D Core Kit. We changed the name because when I talked to companies here about 3D Core Kits, they didn't seem to understand. They would always come back that it was shaped foam. Having foam core precut into kits has been done for many years. What we are doing goes further, thermoforming the foam into preshaped pieces to fit each boat hull."

But isn't it expensive having precut foam that is also preshaped? "There is a cost," concedes Bonnefon, "but there are companies that value the improved hull performance as well as increased production efficiency — it's almost five times faster to install a kit because it's preshaped. And customers also see a roughly 20-25% weight reduction because the preshaped foam doesn't need to have all the cuts to enable bending, but which also absorb resin."

Bonnefon notes these advantages are well known by builders of racing yachts. "We're not reinventing anything. We are just industrializing the process, making it easy for boatbuilders to access this technology. We are also reducing waste because molds don't have to be built for this thermoforming or disposed of afterward. We are using the digital file from the builders to guide the adaptable molding system. And we reuse this over and over to make all of our Shaped Foam Kits and composite panels, so we have a very low carbon footprint. This process also doesn't use much energy. The actuation happens in minutes and we're currently using infrared heating when needed."

He notes that beSpline has qualified for green technology funding in Canada and also won the innovation award at the 2023 IBEX boatbuilding show. It also announced its partnership with Boston Boatworks (Charlestown, Mass., U.S.) which is integrating beSpline Shaped Foam Kits into its newly launched BB offshore series (Fig. 2).

FIG. 2 Shaped foam for innovative boats

BeSpline supplies its Shaped Foam Kits to innovative builders such as Lyman Morse (top) and Boston Boatworks (bottom), using each boat's 3D CAD file to thermoform cut foam pieces to the precise shapes needed for the hull, speeding installation and improving hull weight and performance. Source | Boston Boatworks

Boston Boatworks and Shaped Foam Kits

Boston Boatworks is in its 28th year as a builder of advanced composite, high-performing yachts, says CEO and co-founder, Scott Smith. "We started out building custom race boats and blue water performance cruising boats using post-cured, vacuum-bagged epoxy prepreg sandwich construction," he explains. "We used our own wetpreg machine with stitched biaxial glass fiber skins and we thermoformed ATC's CoreCell foam core [now Gurit, Wattwil, Switzerland] by hand to achieve the slam load dissipation advantage that a plain sheet of foam has over foam core with cuts in it. We would heat the foam in an oven and vacuum bag it onto the hull plug. It was labor- and time-intensive, but we took weight out and improved the mechanical properties of the hull."

"Prior to our current series production of the Zurn-designed *Daychaser 48*, a luxury USCG-certified commercial passenger vessel built with our partner the Barton and Gray Mariners Club, Boston Boatworks built the first 340+ high-performing motor yachts for MJM Yachts, most of them ISO CAT A ocean-rated,"

notes Smith, "all using epoxy construction. Now, we're introducing our BB offshore express cruiser series, designed with a priority on offshore safety, comfort and range. We're starting with a 44-foot model and then following with a 52-foot model."

Smith notes these boats, "will also have a fit and finish that puts them in a class by themselves. So, we wanted to continue to reduce weight and improve performance and safety margins. We want to use thermoformed foam core, but we're also seeking the efficiencies and value of series production for dozens of boats per year. To do that, we are taking advantage of advances in manufacturing like adaptive mold technology. The same 3D CAD file that controls precision throughout the build of our boats is what beSpline uses to create the 3D thermoformed core kit. This matches what we were doing by hand, but without the elapsed time and the labor-intensive approach."

Smith notes a BB series boat will start every 6 weeks. "And we couldn't do that if we couldn't cycle the hull molds," he explains. "With beSpline, we can do that *and* improve the properties." These will be 40-knot offshore vessels, built with E-glass/epoxy (Pro-Set, Bay City, Mich., U.S.) wetpreg sandwich construction — except for the solid keel centerline and chines — and a lot of carbon fiber laminate in the topsides up to reduce weight. Smith notes the glass laminate hull gives impact resistance and is quieter through the water than a carbon fiber laminate.

"I think it's fitting that we started Boston Boatworks almost 30 years ago," he continues, "based on the foundational work that co-founder Mark Lindsay did in the '70s and '80s, adapting DARPA aerospace epoxy construction techniques to build boats that are lighter, stiffer, stronger and more durable. And it doesn't surprise us that Regent [North Kingstown, R.I., U.S.] is using the same techniques for their *Seagliders* and is also using beSpline."

Here, he refers to Regent's electric propulsion, low-altitude flying ground-effect vehicles being commercialized to carry passengers along coastal routes. The company has announced $8 billion in seaglider orders from airlines and ferry operators on six continents. "Having one of our suppliers also participate with Regent in an aerospace segment of the industry is something our clients understand and appreciate."

Bonnefon says he's very grateful to Boston Boatworks, "and for the trust they've put into beSpline. It's already been a great experience, with our teams working together on the engineering and fine-tuning our products for their operations." He notes beSpline's work with other high-performance boatbuilders, such as Lyman Morse and with Moore Brothers on the initial prototypes for Regent: "I'm looking forward to the continued success of these boats in 2024 and for our Shaped Foam Kits being shown to the world."

Innovative solutions for architecture

Construction/architecture is another key market for beSpline "with so many opportunities," says Bonnefon. "For example, we are fabricating cladding for a U.S. company that specializes in architectural stairs. This is for a four-story set of stairs, for a spectacular building in New York City, and we are looking at a second project as well. We can give architects access to curves and different 3D shapes without the time and cost of making molds. And this makes a big difference to help them win projects. For example, compared to 3 months for steel panels, which I could barely lift, our composite cladding takes only 3 weeks and is so much lighter that less structure is needed in the stairway, which further reduces time and cost. So, that was an easy decision for the architect." »

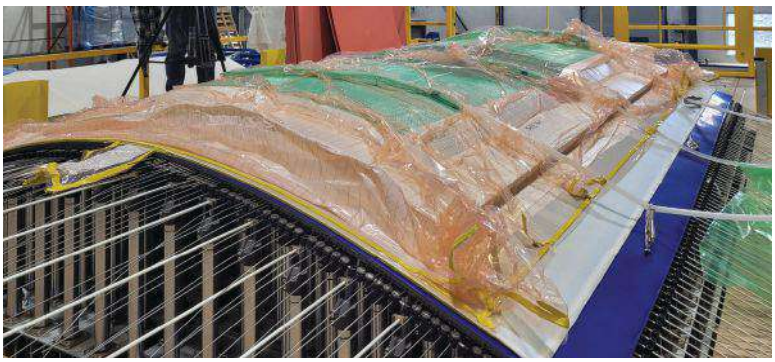
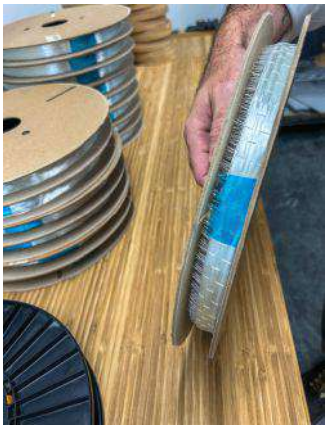


FIG. 3 Innovating composites for new markets

BeSpline uses its 7 × 11-foot adaptable mold (top left) to make felt-faced acoustic panels for ceilings (top right), domes for simulators (bottom left) and modules for customized tracks for motocross events (bottom right). Source | beSpline

FIG. 4 Innovating materials

Addcomp worked with Texonic to develop new UD tapes for AFP-XS customers for improved performance and recyclable cardboard spools. Source | Addcomp



"But our panels are also a good fit for curved walls and ceilings," says Bonnefon. "And we've also produced curved acoustic panels." These are sandwich panels with felt facings that are shaped into wave-shaped strips using the adaptable mold. Suspended from ceilings, they provide aesthetic but efficient sound dampening. They can also pass the UL 94 flammability test with 6-millimeter-thick felt facings bonded to Gurit's Kerdyn recycled PET foam core. Prototypes are being trialed by a very large multinational supplier of acoustic ceilings for commercial buildings and airports.

"The next step for us in architecture would be to make exterior facade panels and cladding for bridges," says Bonnefon. "But for now, we are concentrating on interiors and meeting the industry's demand for more ecological materials. The embodied energy of our products is much less than many conventional materials, but we are also using VOC-free resins." For the stairs, beSpline is using Acrylic One (AOne) from Active Composite Technologies (Stellendam, Netherlands). It has also completed thermoforming tests with Elium from Arkema (King of Prussia, Penn., U.S.) and is now prototyping composite panels with a wood veneer finish.

Simulator domes, X-Track

BeSpline is also making cockpits and domes for simulators (Fig. 3, p. 29). "These are essentially large composite screens," explains Bonnefon. "Instead, we make panels and attach them together, providing a smooth, curved surface onto which they can project the simulations." BeSpline provides a good solution here because simulator manufacturers don't normally produce multiple domes of the same type. "Using our panels eliminates molds so they can afford to make one dome at a time," he says. "This saves tens of thousands of dollars for tooling that may or may not be reused. And we make the simulator cockpits in the same way as the domes, assembling them into a finished product that looks like a real cockpit."

Another niche market is making indoor tracks for motocross races and X sports events. This is for a local company with a patented approach called X-Track. "Instead of bringing loads of dirt into the middle of a downtown arena, you use a lightweight modular track made of aluminum and composites," says Bonnefon. "We thermoform foam core, lay that up with glass fiber skins and infuse the 6 × 10-foot composite sandwich panels. We then attach these to aluminum frames. There are currently eight different shapes that they can mix and match to make a course, allowing them to customize tracks without building molds. If one of their customers wants a different bend or size, we can make that quickly."

Touring the beSpline/Addcomp facility

Bonnefon begins in the company's lobby, where various Shaped Foam Kit pieces and composite panels are displayed. "For the architects, we've started to develop different kinds of finishes," he says, pointing to a panel made with AOne acrylic resin with sand added to replicate limestone. The one next to it was made using vacuum infusion of flax fiber and Gurit's Prime 37 bio-epoxy resin and recycled PET foam core.

Next, we walk into the facility's 930-square-meter main production hall and up onto the mezzanine which houses the adaptable mold system (Fig. 3, p. 29). Sized 3.6 × 2.2 meters with 600 actuators, it can form a 350-millimeter radius of curvature. "We have another one on order that will be slightly smaller, but with higher resolution to achieve a radius of curvature between 150 and 200 millimeters," says Bonnefon. "This will be dedicated for thermoforming core. And we designed this mezzanine so that we can extend it to accommodate more molding systems as we grow."

As we walk around the molding table, technicians are laying up stair cladding segments using the AOne acrylic resin. Bonnefon points out the lack of smell and VOCs, "and it's ready to demold in 45 minutes. Right now, we are making about three panels per day, but we can increase this rate, if needed." After demolding, the panels are painted and readied for shipping. "When we make the sandwich panels, we integrate flanges and this allows us to connect the panels for the finished cladding. It sounds easy, but it took us a while to optimize how to do this."

Addcomp AFP cell assembly

We walk down from the mezzanine and through a door that leads from the open production hall into an enclosed smaller area where Addcomp AFP cells are assembled. "This system is going to Purdue University," notes Bonnefon. "It will be approximately 14 × 16 feet. We just received the robot last week, a FANUC R-2000 [Rochester Hills, Mich., U.S.]. We have been using smaller models, but Purdue wanted to have a large robot so they could use heavier equipment with it in the future. We have started to stake where the fences will go and setting up the rotary table to laminate on top of."

> "Our goal is to lower the barriers for SMEs to implement bespoke composites automation and advanced technology."

Each cell is different, notes Bonnefon. "We do have a standard 10 × 10-foot cell but sometimes the customer wants a larger cell or a different robot. So, we do work with them to customize the cell, and then we first build the system here, making sure everything works. We bring the customer in and get acceptance, and then we ship it and do the installation and commissioning at the customer's site. That typically doesn't take more than a week once we get there."

The system is also easy to install, says Bonnefon, because it has been designed that way. "It is the simplest, easiest-to-use system on the market. For example, it only takes us a couple of days to teach a technician how to use it. The system, in fact, has been designed around the user, including the software, which is open-access, simple, user-friendly and it works well. It gives the user flexibility to build their own scripts if they want to and access digital twin capabilities for real-time quality control. Most users start simply, building their expertise in laying up single tows and then simple laminates, and then move quickly from there."

"After the system for Purdue, there is one for the Polytechnic Montreal which we will be installing shortly," he continues. "And then CET Composites in Rhode Island is the first industrial company to purchase an Addcomposites system here in North America. We then have another another industrial group in discussions for installation in 2024 as well."

Materials and future developments

We turn from the AFP cell being assembled for Purdue and walk a few step to where a unidirectional (UD) carbon fiber fabric sits on a loom (Fig. 4). This is being slit into tapes and was developed with Texonic (Saint-Jean-sur-Richelieu, QC, Canada), says Bonnefon. "The idea was to develop the ability to better position dry fiber using the AFP-XS system. We also have a glass fiber version. We use thermoplastic filament to hold the UD fibers together and also some thermoplastic binder so that the tape adheres as it is heated and applied during layup. We wanted to have a fabric that is easy to use for our North American customers, and that is also easy for us to cut and convert into spools. So, we developed this system in-house to provide dry fiber tapes loaded onto enviro-spools made with cardboard, which we can recycle when the spools are empty."

Bonnefon points out that with the AFP-XS system, "you can lay down dry fiber, thermoset prepreg or thermoplastic composite tape. So, the user can play with different kinds of materials and create a wide range of layups. For example, we are working on a project with CDCQ and a bike company in Montreal, to explore different types of tailored thermoplastic composite preforms for production of bike frames and other components such as handlebars."

"We will continue to develop materials and capabilities," says Bonnefon, "and are working with a lot of different companies, from boatbuilders and mobility companies to architects and major players in the construction supply chain. We see growing opportunities as these companies understand what our beSpline and Addcomp technologies can provide. And there is a good connection between these — in the future, we could see Addcomp robots applying AFP layups onto an adaptive mold. We will continue to advance what is possible with composites." CW

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Read this article online | short.compositesworld.com/BeSpline-Addcomp-pt

ABOUT THE AUTHOR

CW senior technical editor Ginger Gardiner has an engineering/materials background and more than 20 years of experience in the composites industry.
ginger@compositesworld.com

Next-gen material production system

Cygnet Texkimp's Multi Roll Stack towpreg and prepreg processing line. Source | Cygnet Texkimp

Manufacturing tech for scalable Type V hydrogen tank fabrication, CFRP lifecycle management

Cygnet Texkimp's Multi Roll Stack and composite recycling technology catalyze the ASCEND program's mission to optimize aerospace, automotive hydrogen storage and CFRP sustainability.

By Stewart Mitchell / Contributing Writer

» In the quest to decarbonize the mobility sector, hydrogen stands as a developing cornerstone fuel due to its extreme energy density of 120 megajoules per kilogram. However, this high energy-to-mass ratio is starkly contrasted by its volumetric energy density, a mere 8 megajoules per liter under ambient conditions. Such a paradox necessitates sophisticated storage systems that safely contain hydrogen at pressures of 350 to 1,000 bar or at cryogenic temperatures of -253°C (-423.4°F).

Solutions currently range from Type I all-metal tanks, hindered by weight and capacity constraints, to the more advanced Type III and IV systems, which employ a metallic or polymeric liner respectively, enveloped in carbon fiber-reinforced polymer (CFRP) using epoxy resin. Yet, the future beckons with widespread adoption of Type V tanks — linerless, full CFRP constructions representing a significant leap in weight optimization and volumetric efficiency.

Type V tanks, while revolutionary, face unique challenges. Consider that hydrogen molecules have a kinetic diameter of approximately 2.89 Ångströms, rendering them difficult to contain. Type V tanks must inhibit the permeation of hydrogen through the intricate layers of CFRP laminates. Moreover, their high-pressure conditions contribute to the risk of microcracking and delamination, exacerbated by the absence of a liner to serve as a mechanical buffer.

While Type V tanks are gaining adoption in space vehicles, including launch rockets and lunar landers, they still need to be optimized for hydrogen storage in mobility vehicles. Manufacturing these linerless structures is complex, and current production rates are insufficient for mass adoption, which also leads to higher costs. Therefore, automating and optimizing CFRP filament winding machinery for high-rate Type V tank production to minimize cycle times and material waste is imperative.

Addressing high-rate CFRP manufacturing

The ASCEND (Aerospace and Automotive Supply Chain Enabled Development) consortium was established to enact change in composites-intensive component development for high-volume markets (see Learn More). This cross-sector initiative, partially funded by the U.K. Government, bridges the aerospace and automotive industries to pioneer innovations in lightweight design, material systems, automation, electrification and multifunctional integrated structures. The 3-year program started in 2021 with an ambitious objective: to elevate as many of its research areas as possible to technology readiness level (TRL) 6. This involves demonstrating key rate targets at the prototype level, particularly for propulsion systems, in both automotive and aerospace sectors.

Cygnet Texkimp (Northwich, U.K.), a specialist in advanced material manufacturing machinery, occupies a pivotal role as a consortium member, with expertise that aligns with ASCEND's theme of "rate-capable automation." Its contributions to this initiative are distinctly geared toward achieving material manufacturing speeds that transcend current industry boundaries without sacrificing quality. The company is focusing on future material systems and high-rate-capable CFRP production methods which have potential to enable high-speed production of Type V hydrogen storage vessels, and thus, widespread adoption of hydrogen as an aerospace and automotive fuel.

Cygnet Texkimp has invested in developing next-generation material production systems in collaboration with other ASCEND players, namely GKN Aerospace (Redditch, U.K.) and McLaren Composites Technology Centre (Sheffield, U.K.). The initiative also examines the complete lifecycle of composites used within the automotive and aerospace industries. Moreover, it includes designing and implementing recycling and end-of-life composite fiber recovery solutions, closing the sustainability loop. Cygnet Texkimp has developed two systems within the ASCEND program: the Multi Roll Stack machine and a CFRP recycling system.

Multi Roll Stack evolution

Over the past decade, Cygnet Texkimp has deployed more than 30 production lines for unidirectional (UD) and woven fabric thermoset prepreg across the aerospace, automotive and industrial sectors. In a significant 2021 milestone, the firm introduced the Direct Melt Impregnation Thermoplastic Composite Line for producing high-quality thermoplastic composite prepregs, accommodating a broad polymer spectrum ranging from polypropylene to polyetheretherketone (PEEK). Cygnet Texkimp's Multi Roll Stack is a derivative system optimized for the high-rate manufacture of CFRP within a filament winding cell optimized for Type V hydrogen storage tank manufacturing.

The filament winding cell is an assembly of interrelated machinery that collectively executes a gamut of functions, including spindle management, tie-on and tie-off operations, real-time splicing, resin dispensation, mandrel management, filament winding, curing, product quality inspection, traceability and product packaging. By integrating these independent tasks into a unified cell and coupling them with a monitoring apparatus, the system can achieve high-rate automated fulfillment of filament-wound products while upholding stringent accuracy and repeatability.

CFRP machine design

The Multi Roll Stack is engineered for precise fabrication and slitting of UD and woven fabric CFRP prepregs and towpregs, serving as the material feedstock for the filament winding cell. However, rather than relying on separate compaction stations arranged in a horizontal line, the Multi Roll Stack integrates multiple impregnation rollers within a single compaction module, vertically arrayed in an S-wrap configuration.

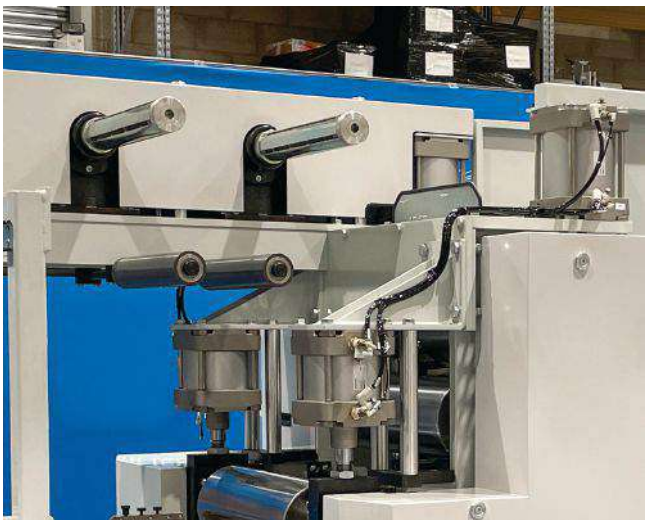
"The Multi Roll Stack's architecture was designed to increase the material's contact with the heated rollers to maintain consistent temperature throughout the manufacturing process," explains Cygnet Texkimp's CEO, Luke Vardy. "The S-wrap roller configuration features short pathways between rollers, almost eliminating the heating/cooling cycle seen in other inline prepreg technologies." This vertical alignment of rollers within a singular compaction module also offers a considerable benefit in energy efficiency as the S-wrap configuration removes the need for multiple drive motors »

Slitting and winding

Cygnet Texkimp's Slitter Spooler Rewinder at the company's U.K.-based Innovation Centre. Source | Cygnet Texkimp

and heaters. The result is a quantifiable reduction in energy use — exceeding 50% when contrasted with traditional compaction methodologies. "This development gains prominence in light of escalating energy costs and a heightened emphasis on the environmental impact of manufacturing technologies," notes Vardy.

The Multi Roll Stack is induction motor driven, operated in speed control rather than torque, configured for operational efficiency. Induction motors can freewheel, enabling operators to handle materials without disengaging electromagnetic components. That contributes to reduced processing time and minimizes the risk of material damage. Vardy underscores the precision that speed control provides in managing material tension. "The tension exerted on a fiber during its transition from one roller to the next is critical for the quality of the material produced," he explains. "Motors operated in speed control offer precise tension governance vital for optimizing resin-to-fiber ratios. This parameter is rigorously managed by the S-wrap design, which considerably influences the mechanical properties of the resulting composite material."



Configured for operational efficiency

The Multi Roll Stack roller configuration increases the material/heated roller contact throughout the production process compared to other systems.
Source | Cygnet Texkimp

Single cell for filament winding

Cygnet Texkimp's four-axis filament winding machine for producing CFRP hydrogen storage vessels. Source | Cygnet Texkimp

Material results

Cygnet Texkimp's Multi Roll Stack machine can produce prepregs with a coat weight of 112 grams/square meter while achieving a 10 meter/minute production rate. "This signifies a doubling in the production speed compared to traditional machines," says Vardy. "And yet the output from the Multi Roll Stack meets the properties required for aerospace-grade composite materials for Type V hydrogen tank construction — uncompromising strength-to-weight ratios, precise resin distribution and thermomechanical resilience."

The consistent temperature of the Multi Roll Stack's S-wrap design also affords distinct advantages for fabric constructions, especially during subsequent forming processes. Vardy elaborates: "The S-wrap can automatically open and close the fabric weave, effectively preparing the material for draping around molds in its final forming process. This process ensures uniform resin impregnation, a factor critical for enhancing composite mechanical properties."

Material impregnation with epoxy resin also benefits from the S-wrap's thermal consistency, accelerating production timelines. "The S-wrap heats epoxy resins quickly and uniformly, inducing them to flow seamlessly into the fabric, thus expediting the time to production," explains Vardy. "Such resin flow and curing optimization positively impact interlaminar shear strength, a critical property for high-performance, filament-wound composite applications."

Cygnet Texkimp's Multi Roll Stack is combined with the company's four-axis filament winder technology to enable Type V tank manufacturing within one filament winding cell. Design options for Type V tanks are still under rigorous evaluation by the various industries looking to employ them. "Most manufacturers have reached the stage where they are determining tank dimensions and anticipated wall thickness," says Vardy. "The layup configurations often involve traditional fiber angles of +/- 45 degrees and interwoven layers at +/- 90 degrees. The choice of fiber orientation is a subject of ongoing research, especially considering its significant impact on the tank's burst pressure and fatigue life." He notes the filament winding cell enabled by Cygnet Texkimp's ASCEND developments can manage all these orientations and offers flexibility for future designs.

End-of-life technology

In an industry where material performance is paramount, the sustainability facet of composites often takes a back seat. However, Cygnet Texkimp is challenging this narrative with its composite recycling system where valuable fiber can be reclaimed from the

Reclaiming polymers

Composite recycling system that uses a thermal-cyclic form of pressolysis called DEECOM. Source | B&M Longworth

resin matrix without burning, chopping or weakening. The system leverages a B&M Longworth (Edgworth, U.K.) patented thermal-cyclic form of pressolysis called DEECOM to reclaim value waste streams from thermoplastic and thermoset polymers, allowing for reprocessing and remanufacture into high-grade items while meeting safety and strength demands.

The DEECOM process uses supercritical steam and swings of compression and decompression to attack the surface area of organic material, causing a physical fracturing of the polymeric contaminant. The thermal and pressure parameters governing DEECOM are extreme, with internal temperatures up to 650°C and pressures as low as -15 bar.

During each stage, the system's pressure and steam content cause resin dissociation, forming a dissolved resin vapor. This vapor is then channeled into a condenser system, traversing a heat exchanger to create a water/resin liquid solution. What remains in the chamber are dry, long fibers, remarkably close in performance to virgin fibers.

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Read this article online | short.compositesworld.com/CygnetTexkimp

More about the ASCEND project | short.compositesworld.com/ASCEND

Cygnet Texkimp's composite recycling system is adept at extracting resin from a broad spectrum of fiber-reinforced polymers, extending from lightweight, thin products to intricately constructed, 50-millimeter-thick aerospace parts. Polymer — in the form of yarn, resin or binder — can be extracted from any component, which can be of metallic, carbon fiber, glass fiber or other composite construction.

"Post-DEECOM fiber sampling indicated retention of 94% tensile strength and 97% tensile modulus compared to virgin fibers," notes Vardy. "The marginal performance deviation from raw virgin fiber performance is typically due to stresses induced during the manufacturing and in-service phases of the component."

While not negligible, the energy cost of fiber reclamation is significantly less than that involved in generating long virgin fibers. Such efficiency gains are not trivial and underscore the economic and environmental benefits of composite material recycling. Cygnet Texkimp envisions incorporating the composite recycling units at the terminal points of its customers' virgin fiber production lines, enabling the recycling of waste products into valuable raw materials for sheet molding compound (SMC) parts or similar components.

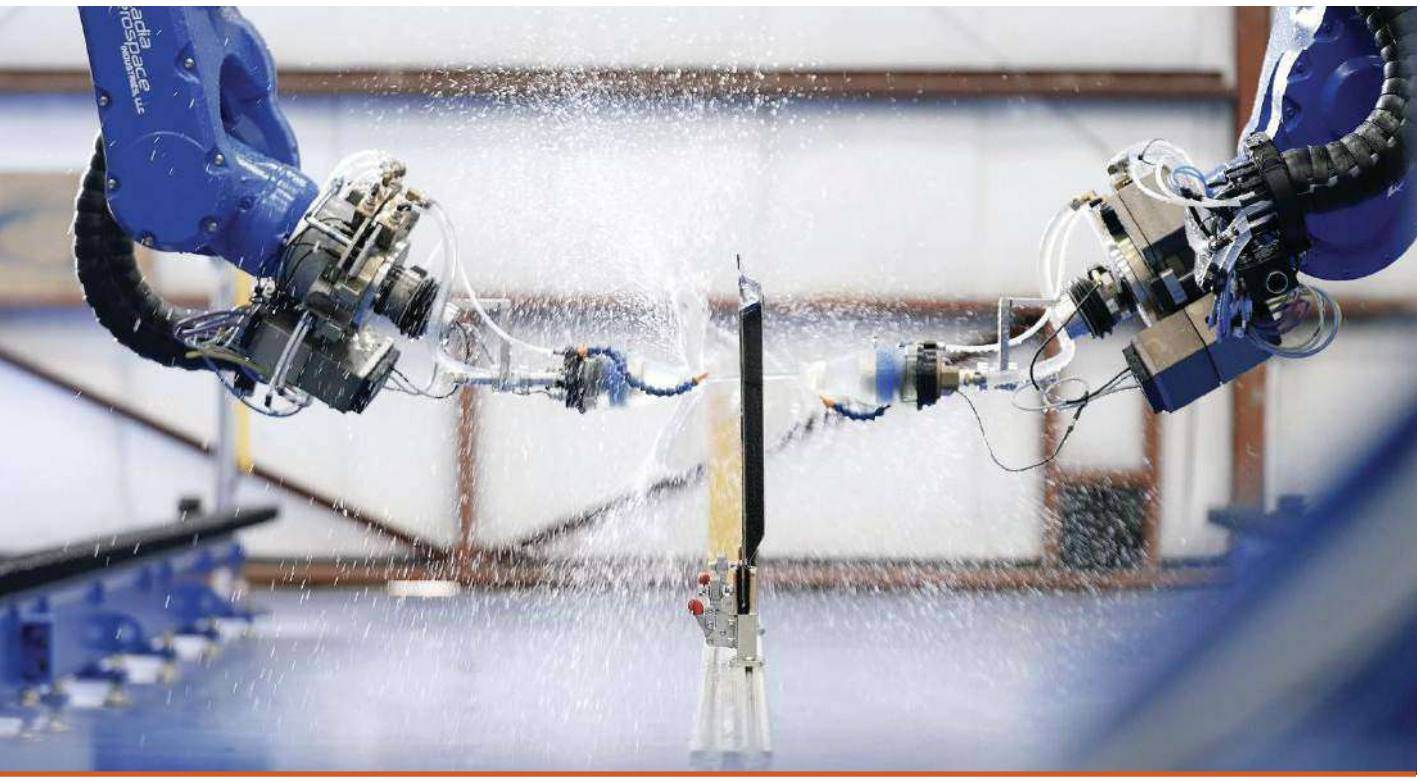
Vardy highlights that the composite recycling system effectively strips fibers from all current forms of a CFRP composite. "It is capable of stripping a single-ply prepreg of its resin in mere hours, and while high-performance aerospace parts necessitate a more protracted process, the fibers can still be reclaimed," he says. "In an industry often described as resource-intensive, our composite recycling system introduces a compelling chapter in the pursuit of sustainability without compromising rigorous material performance standards."

ASCEND first steps toward future composites

Although reticent on specifics concerning how its Type V hydrogen storage tanks will be manufactured, Vardy acknowledges this project's pivotal role in the future of hydrogen energy. "The Multi Roll Stack's high-performance composite production rate epitomizes the ASCEND program's desire for the fusion of speed, cost-effectiveness and uncompromised material quality, crystallizing our understanding of material science across every production phase," reflects Vardy. Meanwhile, he says, the composite recycling system demonstrates how these pursuits can be elegantly balanced with long-term sustainability in a market often dictated by the relentless pursuit of efficiency and quality. These first developments within ASCEND signal a future where composite excellence and sustainability are not mutually exclusive but complementary facets of technological evolution. CW

ABOUT THE AUTHOR

Stewart Mitchell is a Bristol, U.K.-based engineering journalist with experience covering technology in Formula 1, electric and hybrid powertrain and autonomous systems. He has a degree in motorsport engineering from Oxford Brookes University (Oxford, U.K.), and is a member of The Institution of Mechanical Engineers (London, U.K.). **smitchell@compositesworld.com**



Innovation in ultrasonic inspection and nondestructive testing

With increasingly complex structural components working their way into aerospace programs, the need for versatility in inspection and testing capabilities is growing.

By Scott Francis / Editor-In-Chief

» The use of carbon fiber composites in aerospace applications continues to evolve. What started out as a replacement material for metal largely selected for lightweighting has become a material of choice for increasingly complex structural components. As a growing number of structural parts are made with composites and new aircraft such as electric vertical takeoff and landing (eVTOL) aircraft are approaching qualification, quality testing needs are also evolving and nondestructive testing (NDT) must keep pace both with new parts and increased production rates.

Arcadia Aerospace Industries LLC (AAI, Punta Gorda, Fla., U.S.) was founded by Charles Bushman in 2007 to address what he perceived was a gap in the aerospace industry: automated nondestructive testing (NDT) for a growing number of increasingly complex aerospace components made from carbon fiber.

The company got its start with Boeing, using phased array ultrasonic testing (UT) to inspect shear ties. This became the catalyst to developing other relationships with other aerospace companies including GKN Aerospace, HondaJet and GE, and from there Arcadia quickly evolved. While building a foundational business in conventional UT services for aerospace, the company saw an opportunity to help its customers address the growing need for testing aerospace components with complex geometries.

Streamlining inspection, NDT

In addition to conventional ultrasonic testing methods for high-rate aerospace production, Arcadia Aerospace Industries (AAI) specializes in custom solutions for a number of nondestructive testing (NDT) processes.

Source (all images) | Arcadia Aerospace Industries

"When I first started in the industry back in the early '80s, a lot of the composite [aerospace] parts you saw were [selected] basically because of the weight reduction — they were using them for ducts and a lot of non-structural components," says AAI director of NDT Byron Vines. "Today, we've come to understand more about how these composites handle dynamic loading situations."

AAI vice president Jeffrey Phillips agrees. "It seemed like there was a gap in the industry, in particular, a lack of customer-focused customized solutions, whether it be for inspection or machinery. "

Today, AAI performs three main business functions. One is the offering of third-party independent NDT services. Customers can elect to send parts to the company's Alabama-based lab in Tallassee for inspection services based on their specifications or AAI can send out a technician to inspect on location. Overall, the solutions or the inspection methods that AAI specializes include conventional UT, phased array ultrasonics, air-coupled UT, X-ray (both portable and robotic), eddy current testing (ETC) and thermography.

Meeting demand

AAI's robotic x,y,z bridge and dual tower x,z robotic scanning systems are designed specifically for complex contoured aerostructures.

The company also designs custom NDT solutions and systems for large prime and subprime contractors in the aerospace industry with in-house NDT departments in need of automated equipment. Lastly, AAI offers consulting for customers interested in building an NDT department.

"As parts become more complex, the demands for customized systems have also gone up," says Phillips. "That's kind of where we've been able to make a mark in the industry — our customer focus and customized solutions for systems."

A focus on customization

AAI's solutions are developed at its engineering headquarters based in Punta Gorda, Florida — a 34,000 square foot manufacturing space where the company designs, builds and commissions all of the customized machinery for its customers. That same expertise enables AAI to offer specialized services at its Alabama location, which focuses on providing UT services for high-rate aerospace programs.

AAI's ability to both provide NDT services and build inspection solutions is one of the things that makes the company unique. "We know what it takes to inspect parts at volume, and when we have a customer who has a special need for a different method, we have experience on the build side," says Phillips.

Customizing for complex structures

While it is important to note that the majority of composite components that are manufactured in the aerospace community »

typically require either through transmission or pulse echo inspection, there is an increasing need for flexible, outside-the-box solutions. This is especially the case for parts with complex geometries, such as those that have been 3D printed.

"In many cases, customers are looking for a supplement to conventional ultrasonics, and in some cases a new technology is needed," emphasizes Vines.

To develop these, AAI typically begins with inspection of various parts for the customer to determine what may be the best inspection solutions. "We're finding more and more, as the parts get increasingly complex, that conventional UT isn't providing an answer for every part in their catalog," says engineering project manager Mark Pope. "When that's the case, then we expand out to different inspection technologies and go through a testing process — usually by getting in scrap components and performing different test studies on them, verifying that we can see all the defects and determining which methods will be the fastest."

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Contoured part scanning capabilities

AAI's Alabama facility features two 10-axis gantry systems, one dual robot system and one dual robot x,y,z tower system. These four systems can accommodate both large and small components.

"A lot of [companies] have scanners that can do flat panel scanning, but the ability to bring a part in with complex contours and scan that and maintain the appropriate scanning amplitudes is not something that everyone can do," says Vines. "But it's something that we do very well."

The 10-axis gantry system and dual robot x,y,z tower system at AAI's Alabama facility are capable of scanning large aerospace parts that are difficult to process on conventional horizontal scanners.. For example, it is used to inspect the complete fuselage for the *HondaJe*t aircraft. That fuselage is made in two halves, each combining nose (honeycomb sandwich structure), barrel (stiffened panel with co-cured stringers) and tail cone (honeycomb sandwich structure) into a co-cured integral structure. However, before the halves are joined, each must be inspected.

Multifrequency, multidimensional inspection

AAI's 16-axis dual tower x,z robotic inspection system has the ability to perform optical inspection, conventional through transmission/pulse echo and phased array.

Pope describes the machine: "We use a motion controller that allows us to coordinate both sides of the machine very accurately, so that we can track both sides of the component and create simultaneously high quality through transmission and pulse echo inspections."

AAI's system has the ability to perform pulse echo and through-transmission ultrasonic (TTU) C-scan inspections (see sidebar below). While TTU typically provides a lot of data, including a colored spatial plot across the part indicating both location and relative severity of defects, there are cases where it doesn't work. For example, in structures with aramid honeycomb, the highly attenuative core prevents seeing the second skin. Any defects beyond the core aren't visible. AAI's system provides a solution in that it can scan using pulse echo from both sides of the part simultaneously.

Any frequency combination can be used on any of AAI's systems. Typically AAI will use a combination of 1 megahertz and 5 megahertz, with 1 and 5 megahertz used for through transmission and 5 megahertz only for pulse echo. The benefit of through transmission is enabling the scan of thicker, less dense materials yet allowing access to both sides of the part. Plus echo allows access to one side.

AAI can also perform C-scan inspections at 1 and 5 megahertz simultaneously. Other frequencies can be integrated depending on the application requirement. Pope explains that testing processes typically involve running one frequency for the laminate portions of a part and then running the part again at a different frequency for other portions — reinforced core sections, for example. The multiple frequency system affords the ability to scan different aspects of parts simultaneously and collect the information on multiple channels. This can make a huge difference, notes Pope, especially when sometimes running a larger part can take up entire shifts.

"We have the ability to change heads and go from one whole method of inspection to a totally different method of nondestructive testing without dismantling the setup or the tooling. It's a great time saver — sometimes days," says Vines.

The benefit of the tool changer at the wrist of the robot allows the technician to change from one NDT methodology to another in a matter of seconds, greatly increasing the efficiency of the system.

Universal part carts can be used to accommodate many geometry styles and hold multiple parts during a single inspection. If required, AAI has the ability to fabricate custom holding fixtures to properly orientate complex parts.

AAI uses phased array UT in a variety of systems, including immersion tanks and with both flat and curved phased array probes. It can automate inspection to provide one-pass scanning of multidimensional composite components that incorporate radii, angular variations and curvatures, achieving high throughput rates. For example, its squirter system with a 64-element phased array transducer has helped the company significantly reduce inspection time for one part. "It normally takes 40 minutes to inspect with conventional UT," says Pope. "But with this phased array system, we're down to 3 minutes and 20 seconds to inspect that part."

Complex part case history: GKN and HondaJet

A good example of what AAI brings to the industry is its partnership with GKN Aerospace (Tallassee, Ala., U.S.). AAI provides NDT services for products GKN produces for Sikorsky, Airbus, GE, HondaJet and several missile programs. Paul Hurley, GKN's global manager, composite aerospace materials (defense), says the relationship between GKN and Arcadia began several years ago when the GKN site at Tallassee, Alabama, didn't have the ability to conduct NDT inspection on the large fuselage it produces for HondaJet. "This partnership between GKN and Arcadia has allowed GKN to develop and maintain this capability on-site," Hurley says. It has also grown from providing NDT for one product on one program to providing testing for five programs at a rate of approximately 1,000 parts per month.

Hurley adds that leveraging AAI's NDT enables GKN to focus on its own core competencies in composite aerospace structural »

SIDEBAR

Conventional, phased array and air-coupled UT*

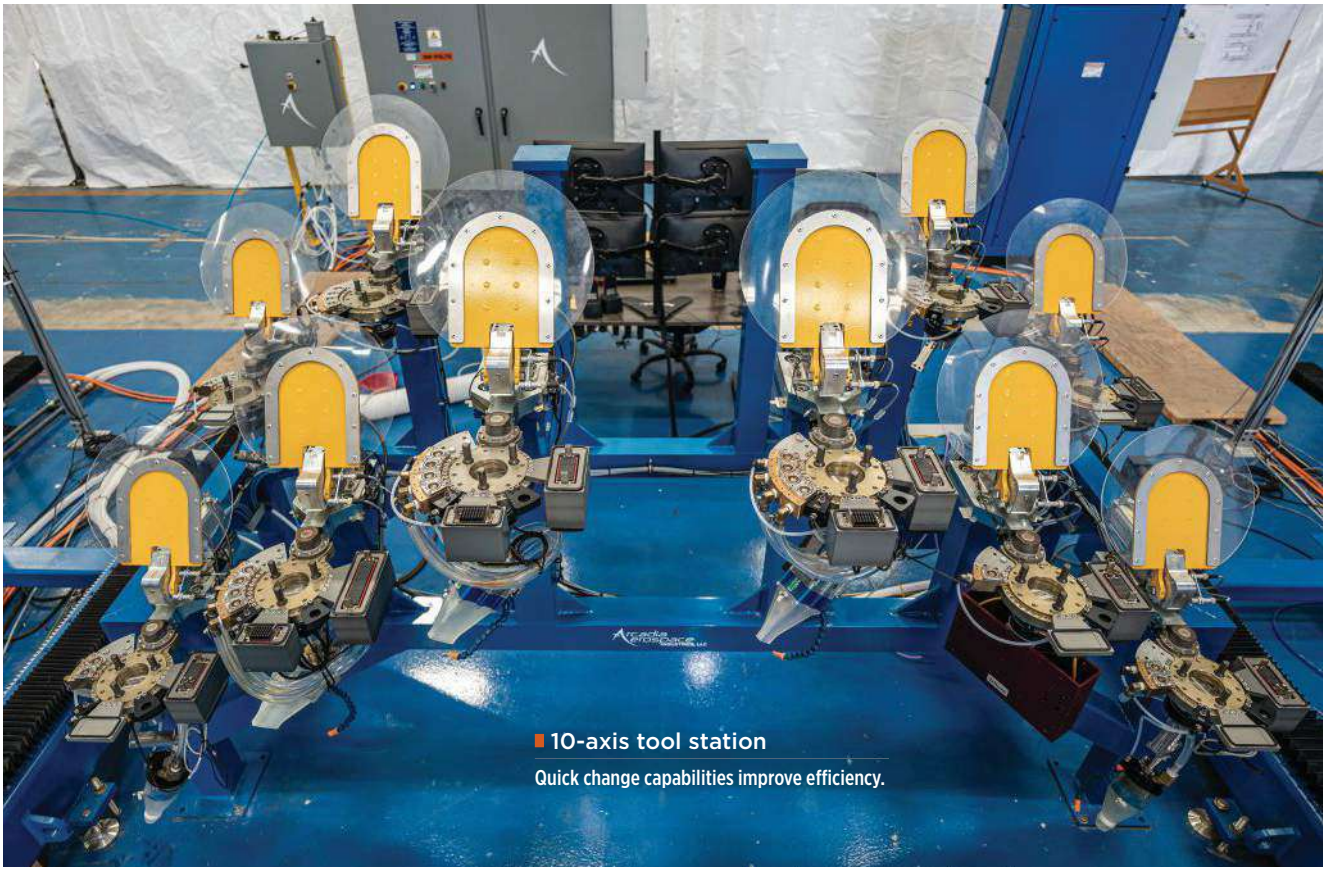
UT works by sending high-frequency (0.5–25 megahertz) energy waves into or through a laminate. The primary methods are pulse echo, which measures reflected waves sent and received with the same probe, and through transmission (TTU) which uses a transmitter probe to send waves through the laminate thickness and a receiver probe to measure them on the other side. Pulse echo is limited to finding the first defect, but is good at defining the depth of the defect. TTU is less sensitive to small defects but can see all defects through the part within the sound path. It can provide size and location of defects but not depth.

Phased array UT can dramatically reduce inspection time while providing excellent detection of small defects, including location and depth. A phased array probe uses multiple transducer elements aligned in a single housing. By firing the elements at slightly different time intervals, the sound waves can be focused (depth) or steered (left, right or at an angle) toward a specific location. Probes commonly have 32 or 64 elements with the latter measuring 40 × 25 millimeters, for example, although sizes vary but length is typically below 100 millimeters. Larger probes with 128 elements are also available, but not as widely used.

Air-coupled UT does not require water, gel or other couplant as all other UT methods do, but also typically have limitations in resolution and what defects they can see.

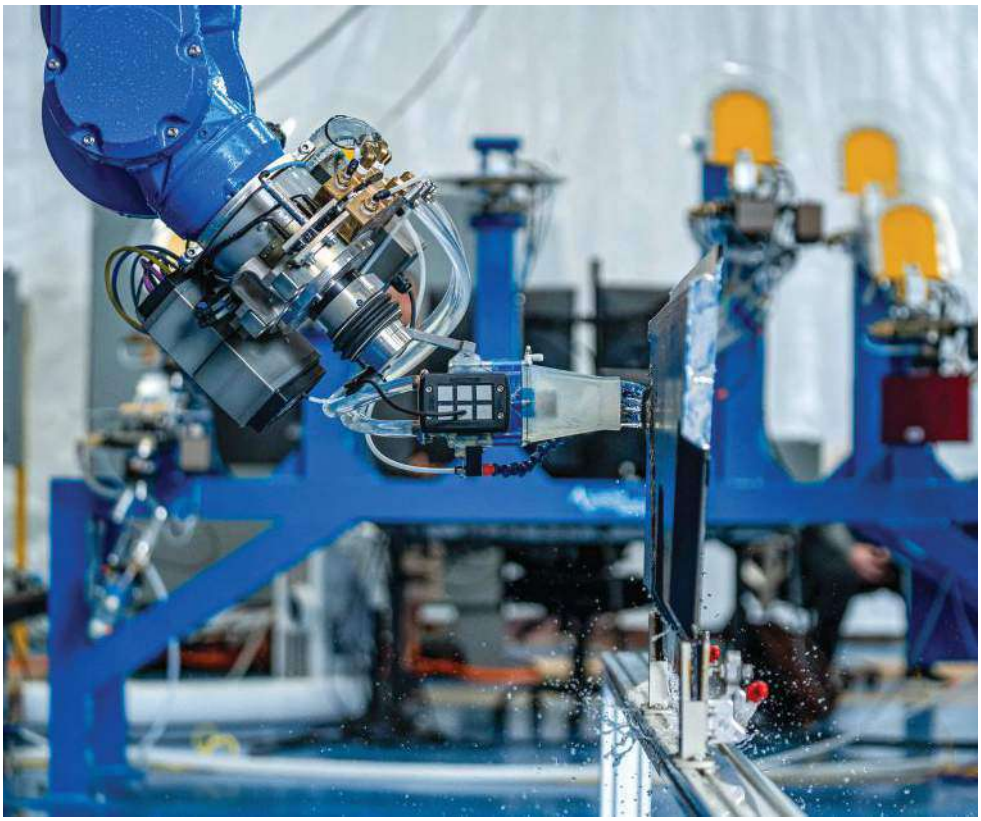
Immersion in water tanks is also a widely used UT system configuration, enabling increased clarity in resulting scan images, but should not be used with sandwich structures, for example, and can require lengthy scanning times.

** This section is excerpted from the second edition "Essentials of Advanced Composite Fabrication and Repair" textbook developed by Abaris Training Resources.*



10-axis tool station

Quick change capabilities improve efficiency.



Hitting all the boxes

AAI's phased array capabilities allow for multidimensional one-pass scanning of complex parts.

design, engineering and manufacturing. "Arcadia was able to develop highly automated solutions to customer-directed material testing requirements for GKN. Additionally, Arcadia is also working with GKN to introduce advanced robotics inside our aerospace manufacturing facility in Alabama. This is a true partnership, where we can receive the benefit of allowing each company to focus on its core competency in support of a common cause."

Evolution of an industry

It's an interesting time for the aerospace industry. Composites are now used on a wide range of aircraft programs and

increasingly in structural applications. They have already been selected by numerous advanced air mobility companies, where collaborations with automotive companies point to ambitious plans for high-rate production of eVTOLs and other new aircraft. All of these trends will in turn influence production processes in commercial aerospace. Pope points out the trend toward bonding and welding instead of using fasteners, which poses inspection challenges, especially the ability to see kissing bonds and properly welded joints.

Vines speaks about this evolution in terms of how parts are being designed with inspection in mind as part of the production process. "Back in the old days, when I was first starting engineering, you'd design a part, build it and then try to come up with an inspection plan," he says. "Now, a lot of that planning is done in the upfront design of these parts."

As the aerospace market continues to evolve, increased efficiency is crucial — and AAI is ready to meet those needs by solving NDT challenges, providing customized solutions for inspecting complex parts and increasing the throughput, sometimes with 8-10 times less inspection time.

In addition, GKN makes the point that lessons learned from improved inspection help move the industry forward. "Arcadia's growing expertise on aerospace material testing requirements also translates into better support to GKN across multiple programs," says Hurley. "Ultimately, our customers can rely on both GKN and Arcadia for precise and reliable testing that ensures high-quality products delivered on time with the appropriate documentation to prevent any non-conformities. The NDT information received from Arcadia allows the GKN engineering team to discuss, with precision, the material characteristics of GKN products with both internal and external inspection teams. Obviously, there's value for an engineer to better understand various material characteristics (i.e., porosity, curing characteristics, etc.) to enable them to translate that information in order to improve both part designs and the manufacturing process according to customer specifications."

AAI thrives on its role in supporting the industry. Phillips sums it up: "We're not developing new NDT technologies. What we're doing is integrating the needed technologies and applying them to our customers' problems in ways that are innovative — tool changing, multiple NDT methodologies, the configurations of the machines that will fit specific applications. It's our integration ability, our ability to stay up with the latest technologies and our ability to customize that really sets us apart in the industry." CW

ABOUT THE AUTHOR

Scott Francis is the editor-in-chief of *CompositesWorld* and *Products Finishing*. He has written for numerous publications including Writer's Digest, HOW and Popular Woodworking.
sfrancis@compositesworld.com

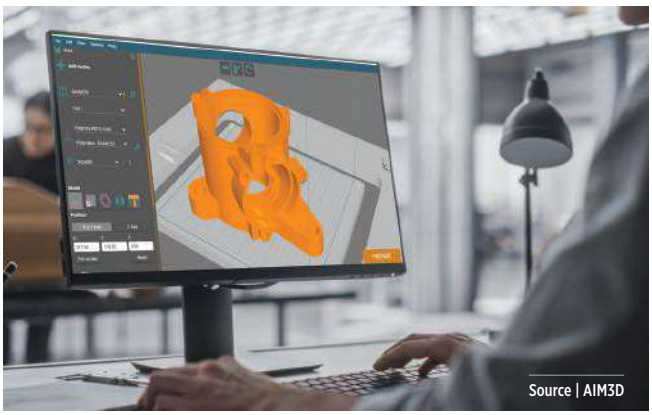
New Products

» 3D PRINTER SLICER SOFTWARE

3D printing cross-layer filling strategy is backed by slicing software

A collaboration between Danish software company **Create it Real** (Aalborg, Denmark) and **AIM3D GmbH** (Rostock, Germany) is integrating the Voxelfill process as a plug-in for AIM3D's ExAM 255 and 510 composite extrusion modeling (CEM) 3D printers. The slicing software solution SlicEx, which is based on Create it Real's Real Vision Slicer, will, in the future, enable users to make optimum use of AIM3D's patented Voxelfill technology to overcome inhomogeneous strengths and to achieve selective densities of 3D components made of metals, plastics, fiber-filled plastics and ceramics.

AIM3D's Voxelfill process overcomes inhomogeneous strengths by making use of a cross-layer filling strategy. The layer-based 3D buildup processes currently used in 3D printers often exhibit inhomogeneous strength values. This manifests itself primarily in the form of tensile and flexural strength shortcomings, as well as very brittle behavior along the Z-axis. In contrast, strengths achieved along the X and Y axes with some processes are already close to the strengths possible with conventional injection molding. AIM3D has already demonstrated this with the processing of fiber-filled components based on PA6 GF30 material. With the Voxelfill process, AIM3D is taking a new approach that overcomes these inhomogeneous strengths and achieves defined



Source | AIM3D

selective densities in the component. In addition to the CEM process, Voxelfill can also be used for multi-material components and is suitable for constructing 3D components using plastics, metals and ceramics.

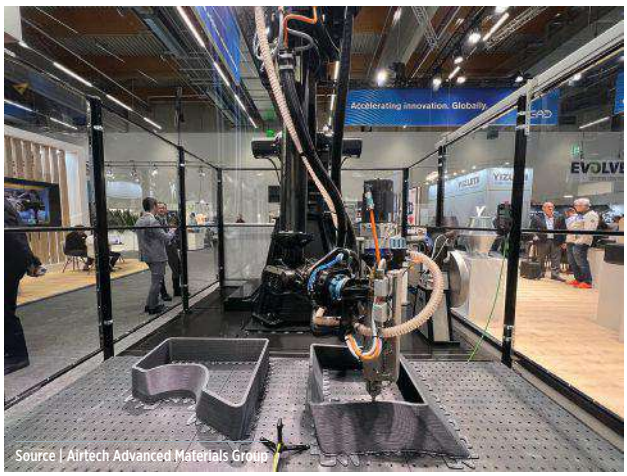
"With the development of Voxelfill, the user now has the possibility to use Voxelfill to improve the Z-strength and the printing speed. However, these modules are currently still under development," Jacob Nissen, CEO of Create it Real, says. "AIM3D is an ideal partner, backed by a strong academic background and a solid theoretical foundation."

aim3d.de/en, createitreal.com

» LARGE-SCALE 3D PRINTING RESIN

Recycled-grade thermoplastic resin contributes to sustainability initiatives

Dahltram T-100GF resin is **Airtech Advanced Materials Group**'s (Huntington Beach, Calif., U.S.) first recycled-grade thermoplastic polymer resin for pellet-fed, large-scale 3D printing. Developed with precision, the material was designed to tackle distinctive challenges of large-scale 3D printing while contributing to sustainability initiatives in the industry.



Source | Airtech Advanced Materials Group

Dahltram T-100GF combines the power of recycled-grade co-polyester resin with the strength of fiberglass reinforcement, resulting in a sustainable material that is suitable across diverse applications, including rapid prototyping, low-temperature molding, trimming tools, architectural structures, casting patterns and more. Airtech says it remains committed to expanding its product line with solutions that drive sustainability and contribute to a greener future through the use of large-scale additive manufacturing (AM) technologies.

Other benefits of Dahltram T-100GF resin beyond sustainability include the resin's strength and durability. The inclusion of fiberglass reinforcement improves the material's strength, promoting good durability and reliability across a spectrum of applications. The resin is also highly versatile, catering to a range of applications from rapid prototyping to architectural structures, offering an adaptable solution for manufacturers across various industries.

Dahltram T-100GF also provides an economically attractive alternative to traditional materials while still delivering performance. Airtech says this makes the resin an option for businesses aiming to streamline their production processes without compromising quality. **airtech.com**

» NONCONTACT INSPECTION

LADAR inspection system streamlines aerospace manufacturing

Automated Precision Inc. Metrology (API Metrology, Rockville, Md., U.S.), a global dimensional metrology solutions provider, announces a novel approach to aerospace manufacturing inspections with its Dynamic 9D LADAR (laser detection and ranging) mounted on an autonomous guided vehicle (AGV). The company confirms its applicability for the inspection of fiber-reinforced composite parts and structures.

Dynamic 9D LADAR is a fast, noncontact measurement system that automates data collection. When integrated with an AGV, the 9D LADAR system offers flexibility and coverage across the manufacturing floor, navigating autonomously and adjusting its measurement height as needed. With a 25-m range and a scanning speed of 0.2 sec/cm^2, the solution precisely captures dimensional and surface geometry data. It maintains 3D accuracy of 25 μm + 6 μm/m (2 sigma).

Joe Bioty, president of API, says the system streamlines aerospace operations, enhancing productivity and efficiency. For example, it eliminates manual inspections, reducing potential human errors and enabling skilled workers to focus on more intricate tasks. The system can also be integrated into existing manufacturing processes and is compatible with third-party metrology software.
apimetrology.com

» CUTTING AND STACKING MACHINE

Fully automated cutting and stacking system enables automated SMC processing

Automotive suppliers and others who manufacture composite parts can increase production as much as 7% with **Dieffenbacher**'s (Eppingen, Germany) fully automated Fibercut cutting and stacking system featuring a quick-change unit. The Fibercut system enables automated processing of sheet molding compound (SMC) materials. Fibercut consists of a cutting unit with a cutting belt, a stacking table and a quick-change unit for SMC on coil or in festoons to further increase productivity. The cutting unit communicates with the stacking gantry or robot and is able to implement complex laying patterns automatically.

"Different cutting patterns can be realized at the same time with maximum flexibility," says Marco Hahn, sales director of the forming business unit at Dieffenbacher. "Using an active compensation cut, deviations in the weight of the material stack will be actively corrected. This ensures compliance with weight tolerances and maximum reproducibility even with the geometric complexity of the SMC layer structure."

The Fibercut can be used in a fully or semi-automated production cell and, in an alternative design, a manual production setup. Additionally, the Fibercut is available as a "transportable system" that can be used flexibly in different production areas within a building.
dieffenbacher.com/en

» RPET FOAM CORE

Recycled PET foam core technology

Armacell (Luxembourg), a global provider of flexible foam for the equipment insulation market and engineered foams, launches ArmaPET Struct GRX, a recycled PET (rPET) foam core technology that improves efficiency and sustainable sandwich structure production.

Entirely made from recycled plastic bottles, ArmaPET Struct GRX offers an optimized resin uptake process, further improving weight and cost. Its thermal and dimensional stability safeguards high-quality production, while high fatigue resistance ensures long-term performance and low lifetime maintenance. ArmaPET Struct GRX also boasts a more homogenous and finer cell structure compared to previous generations resulting in enhanced shear properties.

Extensive testing conducted by Armacell proves that ArmaPET Struct GRX exhibits comparable or even better mechanical performance to its predecessors — for example, its adjusted foam recipe delivers an increase of up to 30% in shear properties. It is available in a wide density range from 100-250 kg/m^3. **armacell-core-foams.com**

Source | SHD Group

» SUSTAINABLE PREPREG

Bio-content epoxy prepreg with flexible processing, 90-day extended out-life

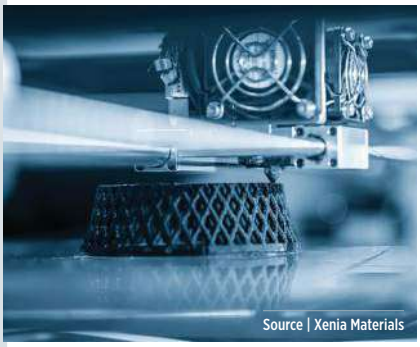
VTB301 from **SHD Group** (Lincolnshire, U.K.) is a versatile epoxy prepreg system with up to 25% bio-content. Curing can be achieved as low as 65°C while still having a room temperature shelf life of at least 90 days. The system can be processed out of autoclave (OOA), through an autoclave or snap cured at 140°C via a press, delivering flexibility for component manufacture.

Development work has showed VTB301 to be capable in multiple forms of processing, across a range of fabric reinforcements and unidirectional formats. Thick-section carbon fiber laminates can be produced with low-temperature oven cures, delivering low levels of voids/porosity. Equally, snap cures can be achieved in under 10 minutes through compression molding in heated matched metal tools.

In validating the extended out-life of VTB301, SHD manufactured panels, via both vacuum-only and autoclave cure, from packs of material aged up to 90 days, before being mechanically tested. Results showed no degradation in values, demonstrating that VTB301 can be stored for extended periods at room temperature (20°C) without losing performance. When considering OOA processing, however, the extent of the workable life will be dependent on material storage conditions and specific laminate requirements.

With increased bio-content, extended out-life and versatile cure capabilities, VTB301 underlines SHD's commitment to support its customers' progress toward net-zero targets. The energy burden associated with the processing and storing of advanced prepreg solutions can be reduced through implementation of this highly novel resin technology, according to the company.

VTB301 joins other systems in the 300-series, which have been developed specifically to enable reduced environmental impact materials while still delivering high-performance advanced composite solutions. Initially, VTB301 will be available from SHD's U.K. manufacturing site, with product rollout from its European and North American manufacturing facilities in early 2024. **shdcomposites.com**


Source | Xenia Materials

» 3D PRINTING MATERIALS

Composites materials for FDM printing

Xenia Materials (Mussolente, Italy) has announced a new range of 3D printing materials, comprised of resins combined with chopped fibers and additives. The materials are made for use in any pellet-based fused deposition modeling (FDM) printer, for large-scale additive manufacturing (LSAM) as well as high-precision production.

Xenia will offer materials dedicated to 3D printing based on its existing range of product families: Xecarb, Xebrid, Xelight and Xegreen. The Xecarb 3DP brand includes carbon fiber-reinforced PEI, ABS and PC. Xebrid 3DP includes a glass and carbon fiber-reinforced ABS. Xelight 3DP includes a lightweight polyether block amide (PEBA), and Xegreen 3DP includes carbon fiber-reinforced PA6 and PA66. According to Xenia, the materials are recyclable and suitable for a wide range of applications and markets including industry, sport, sustainable mobility and defense. **xeniamaterials.com/en**


Source | Markforged

» 3D PRINTER, THERMOPLASTC FILAMENT

Industrial composites 3D printer, carbon fiber-filled PEKK filament

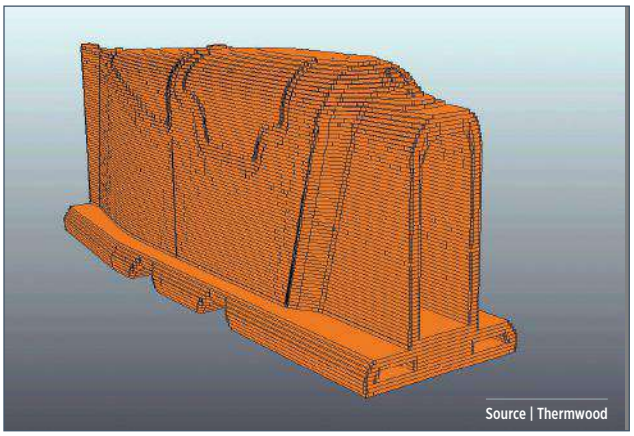
Markforged (Waltham, Mass., U.S.) has developed FX10, an industrial composite 3D printer designed for use on the factory floor, and Vega, a carbon fiber-filled polyetherketoneketone (PEKK) that can help with weight, cost and lead time.

The FX10 is designed to improve manufacturing line productivity and profitability. "The FX10 allows manufacturers to slash original part replacement costs when compared to traditional methods and keep production lines running without worrying about supply chain issues or spare parts inventory," says Shai Terem, CEO of Markforged.

The printer's modular systems are engineered to be expanded and upgraded with additional capabilities. For example, the FX10 has been designed to incorporate a printhead-integrated vision module to capture detailed part images and data to promote part quality and improve printer performance. The continuous fiber reinforcement (CFR) print system delivers high print quality in a heated print chamber, providing print speeds that are nearly twice as fast and print sizes that are up to twice as large as previous Markforged industrial series printers. As a result, the FX10 enables the replacement of metal parts with advanced composites.

Vega is an ultra-high performance filament designed for aerospace manufacturing on Markforged's FX20 printer. It builds upon Markforged's chopped carbon fiber-filled polymers that deliver strength, precision and surface quality. Markforged developed Vega to be compatible with the FX20's CFR technology to deliver aluminum-strength parts.

Vega is said to exhibit optimized surface quality that exceeds most high-temperature plastics used in AM. With a smooth black matte surface finish, Vega offers an as-printed finish for aesthetic aerospace parts. The material resists warping, a problem for high-temperature plastics, and exhibits flame, smoke and toxicity (FST) resistance for high-value applications. **markforged.com**



» CUT LAYER ADDITIVE PROCESS

Low-cost, near-net shape additive process with no CNC programming

Thermwood (Dale, Ind., U.S.) announces a novel process called Cut Layer Additive. This additive approach produces large-format, near-net shape parts at low cost using a less costly additive machine. Unlike large-format additive printers, like Thermwood's LSAM, the new process makes large parts from a variety of materials that can't be printed.

Cut Layer Additive parts are similar to large additively printed parts, in that they are essentially hollow structures made in layers. However, instead of printing the layers, they are instead cut from thick sheets of filler material. One example of this is when making parts for a porous material — such as medium-density fiberboard (MDF) — machined to final size and shape, followed by the addition of a penetrating thermoset resin, such as epoxy, which soaks in and hardens, producing a large "composite" part. Thermwood used this process to produce a 12'-long aerospace tool for the low material cost of $2,000, in less time than it took to additively print the same part.

Cut Layer Additive can also make parts from metal as long as the metal can be CNC routed. To demonstrate this, Thermwood made a large aerospace trim fixture using aluminum. Its walls are only a bit over an inch thick, meaning it used less material.

Thermwood notes that its system has a machine control program called "Machine Intelligence" which has been taught to make Cut Layer Additive parts without the need for a CNC program. To start, users only need to provide a CAD file of the basic part shape wanted. From there, the system will provide the user with a variety of options — how to make it, what material to use, how thick to make the walls, where to split layers for nesting, etc. The machine automatically creates the additive part and the layer segments needed, nests them on the material and creates an internal multi-tool program to cut it all out. Once cut out, the layer segments are reconnected using precision puzzle joints, machined into the segment ends. Dowel alignment holes between layers assure alignment, making assembly accurate and easy.

The machine prints information on each layer segment, such as the layer it's on and how it connects to other segments. This dramatically simplifies sorting and assembly. It also prints a QR code on each layer segment in case operators ever need to recut that particular part. Overall, Thermwood says this cuts down hours of CNC programming. **thermwood.com**

» THERMOPLASTIC TUBES, PROFILES

Continuous fiber-reinforced thermoplastic composite tubes, profiles

Re:Build Manufacturing (Framingham, Mass., U.S.) is presenting a new line of continuous fiber-reinforced thermoplastic (CFRTP) tubes and profiles, which are produced at the company's Oribi Composites facility in Denver, Colorado.

Many composite tubes and profiles available today use thermoset resin matrices to support the fiber reinforcement or use non-continuous fiber reinforcements. These materials, while light and stiff, are typically lower in toughness and durability, and are not recyclable. Re:Build's production technology offers several benefits for users including improved impact resistance, vibration dampening, corrosion resistance, high- and low-temperature resistance, durability and recyclability. Suitable applications for these components include sporting goods shafts, aerospace and automotive tubes and tie rods, medical components, and robotic frames and arms.

Applying highly automated processes developed by Re:Build Manufacturing's automation team, the components are said to meet stringent performance requirements at a lower price when compared to thermoset materials. In addition, by using distinct layup and modeling software, Re:Build's engineers can improve the composite layups virtually, and validate manufacturability of complex parts with less iteration, for a lower total cost.

"By combining a unique, automated layup and forming process with robust modeling and simulation tools, we are able to develop and supply high-performance structural thermoplastic tubes and profiles to fulfill demand in the industry," says Steven Mead, chief commercial officer, Re:Build Manufacturing. "Our customers have been asking us for years for thermoplastic tubes and profiles, and we are now able to offer an affordable, high-volume production solution. When you combine this with our continuous compression molding and high-pressure thermoforming capabilities, Re:Build can design and produce nearly any geometry using continuous fiber thermoplastic materials."

The tubes are available with a range of glass, carbon and Kevlar fibers, and employ a range of thermoplastic polymers, including PA6, PEI, PPS and many others. Customer deliveries will commence in the first quarter of 2024. **rebuildmanufacturing.com**

Multi-material, self-sensing, 3D-printed scoliosis braces

Startup Fited and Brightlands Materials Center have developed a lighter weight, thinner CFRP corrective brace, including pressure sensors made from continuous carbon fibers.

■ In a recent R&D project, the Brightlands Materials Center and Fited developed a 3D-printed, multi-material, sensor-enabled brace concept aiming to increase patient comfort and track how well the brace is working.

Source (all images) | Brightlands Materials Center

■ Scoliosis braces like the pictured Bright Smart Scoliosis Brace prototype are worn by patients for up to 20 hours per day.

Founded in 2017, startup Fited (Maastricht, Netherlands) aims to "automate the design process for patient-specific medical devices," explains founder and CEO Erdem Ay. Before founding his own company, Ay previously worked for a company that made 3D-printed shoe orthotics. He translated this experience into Fited's first target product: 3D-printed braces to correct scoliosis, a condition characterized by a sideways curvature of the spine. Today's braces are typically made from a rigid plastic, designed and molded based on scans, measurements or casts of each patient.

Fited's team spent the past several years working on the company's design and manufacturing technology. To build a Fited brace, first, a suite of digital measurement techniques — including photographs, X-rays and 3D scans — are used to create 3D models of the patient and subsequent brace. The brace itself is printed on a fused deposition modeling (FDM) 3D printer, which also enables one of the most important features of the Fited braces — their abundance of designed-in holes, which make the brace more breathable and lighter weight, and therefore more comfortable for the patient, leading to increased patient compliance.

The company's first braces are made fully from polypropylene (PP), and will be launched in 2024. While developing and testing these initial braces, Ay says the Fited team recognized an opportunity to go a step further with the next iteration. "Because these patients are usually adolescents and are usually required to wear these braces for long periods of time, it's important to understand how the device is working in real time."

Fited therefore began looking into ways of integrating sensor technology into its braces, which led to conversations with Brightlands Materials Center (BMC, Geleen, Netherlands), a branch of research organization TNO (The Hague, Netherlands). BMC had already been working on self-sensing technology using continuous carbon fibers, and in late 2021, Fited and BMC began a collaborative Bright Smart Scoliosis Brace project to incorporate self-sensing carbon fiber technology into Fited's braces.

"You don't want to put a lot of electronics on the outside, which would make it bulky, heavy and uncomfortable, so we proposed sensors we've designed that can be embedded within the 3D printing process," says Fidel Valega, research scientist at BMC. "You can have a minimalistic look but also very good integration of the sensing functionality within the brace."

Along with introducing this technology, the project also aimed to reevaluate materials to produce a brace that is as lightweight and comfortable for the user as possible. Ultimately, the prototype brace was designed to incorporate three materials: unreinforced thermoplastic elastomer (TPE); short carbon fiber-reinforced polyamide (PA); and continuous fiber-reinforced PA. PA was chosen for its greater commercial availability in the needed formats. The materials and thickness vary along the brace, designed for short fiber reinforcement where needed for added rigidity and pressure, and continuous fiber only where the sensors are located. The brace is printed in one shot, using a custom-made APS GmbH (Höchst, Austria) FDM 3D printer.

The addition of fiber reinforcement led to a reduction in brace thickness from 6 millimeters for Fited's PP brace down to 2.5-3 millimeters, and a weight reduction from 700 grams down to less than 500 grams — significantly less than the 1.5-kilogram weight of a traditional brace.

According to Valega, the brace's piezoresistive "sensors" are specially designed, continuous carbon fibers printed directly into the brace. "The continuous fiber is the sensor. We've learned how to combine different continuous carbon fibers arranged and layered in a way in which we can read changes in resistance when we locally deform the fiber. It's like a pressure point."

These self-sensing areas are designed into the most important areas of the brace that need to maintain contact with the patient to realign the spine. For the BMC project, an external micro-controller was wired to the prototype brace to collect and store sensor data. For patient use, Fited has developed a monitoring device with sensors attached to the brace itself to collect and wirelessly transmit sensor data for clinicians to remotely monitor treatment progress.

The R&D project ended in September 2023, resulting in a prototype that Fited continues to evaluate with its own teams and university partners, with the goal of moving toward clinical trials. "We're planning to launch the carbon fiber-reinforced braces as an option in addition to our original product in the next few years," Ay says. CW

SHOWCASE

MANUFACTURING SUPPLIERS

Post Cure

Highlighting the behind-the-scenes of composites manufacturing

Source (all images) | BlueWind Technology

Infused nacelle covers progress wind power capabilities

BlueWind Technology (Pensacola, Fla., U.S.) specializes in the production of high-performance composite components used by various industries — oil and gas, agriculture, transportation, recreational vehicle, tools/fencing and aerospace. Its know-how also resides in the manufacture of nacelle covers that protect the generating components in a wind turbine, demonstrated by the company's recent 1,700 nacelle cover milestone achieved in just 44 months. Using resin infusion and only one set of molds, BlueWind has optimized production to produce 10 nacelles/week, reducing project expenses

Show us what you have!

The *CompositesWorld* team wants to feature your composite part, manufacturing process or facility in next month's issue.

Send an image and caption to *CW* Technical Editor Hannah Mason at hmason@compositesworld.com, or connect with us on social media.

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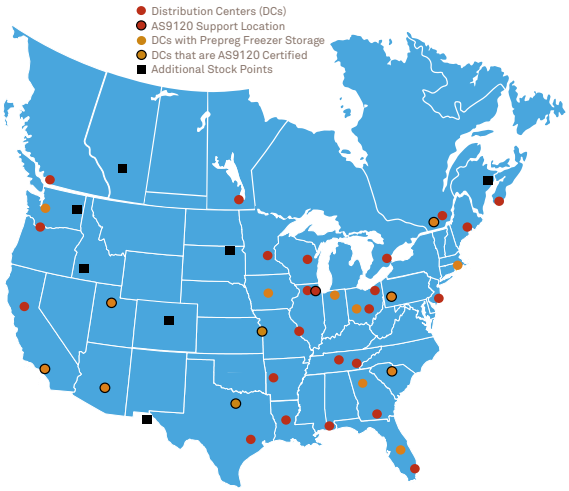

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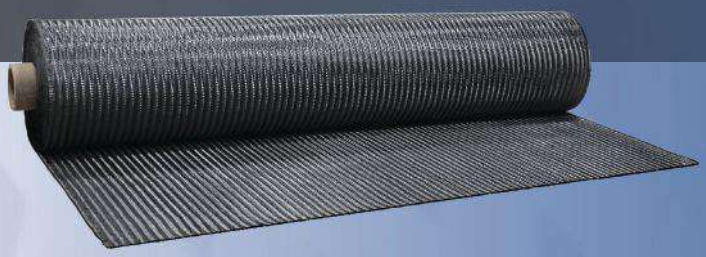
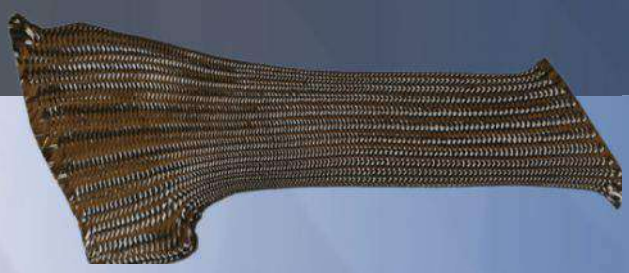


Fabrics

A&P's Braided Fabrics are Optimized to Create the Architectures and Areal Weights Required for Performance, Lightweighting, and Reduced Scrap



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