Real-World 3-D Printing Applications

Auto Market Update

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Disruptive technologies are sweeping the composites industry, changing the way products are made – and the products themselves. Take a look at five innovations, ranging from an RTM process to make structural automotive parts in less than two minutes to carbon nanotubes for space applications.
By Susan Keen Flynn and Evan Milberg

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Predictions on widespread use of composites in the automotive industry always seem to be “five years out.” With advances in technology, processes and materials, is that forecast finally accurate? Experts cite several reasons why it looks hopeful.
By Megan Headley

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Additive manufacturing has garnered a lot of attention in the past few years with the introduction of new equipment and materials. Companies are showing off the possibilities of the technology with 3-D printed tooling, yachts, race car parts and more.
By Mary Lou Jay

About the Cover: Oak Ridge National Laboratory used biocomposite materials to 3-D print this pavilion for the 2016 Design Miami showcase for architects and design professionals.
Photo courtesy of SHoP Architects; Photography by Robin Hill
From the ACMA Chair

Disruption by Disaster and Design

If I could sum up the year the composites industry has had in one word, it would be “disruptive.” Throughout the south, Gulf and the Caribbean, hurricanes have devastated communities and disrupted the way of life of many residents and businesses, including ones in our industry.

However, much like the composite materials we manufacture and supply, our industry is incredibly resilient and can weather any storm. At Core, we activated our contingency plans at our facilities in Mexico and South Carolina. Fortunately, we were not impacted by the storms. I know many of you had similar plans in place and had to experience the impacts of the weather. I hope that everyone was safe and you are back in production!

Hurricane Irma also forced ACMA to postpone CAMX. However, the rescheduled event (Dec. 11-14, 2017, in Orlando, Fla.) will contain much of the same exhibitors, networking and programming, including a general session panel focused on a more positive form of disruption: market innovation.

While natural disasters like hurricanes are not something anyone hopes for, they do provide the opportunity to shine the spotlight on what composites deliver, especially in infrastructure. Strong, durable and corrosion-resistant composites can serve as a replacement to traditional materials in bridges, water structures, electric utility poles and other building structures. Creative Pultrusions’ President/CEO Shane Weyant (page 29) discusses how ACMA is helping grow the infrastructure and construction market for members, and why we as an industry need to advocate for using better materials when our country rebuilds after disasters or replaces structures due to age. The CAMX general session also provides some innovative ways to do this.

Our materials’ potential for market disruption isn’t limited to infrastructure, though. Five end use applications that will change the way we look at everything from wind blades to high-performance aerostructures are highlighted in our lead article (page 12).

I’m thankful that our industry and its employees survived the recent natural disaster disruptions, and I’m sure that all of us – and especially those in areas directly impacted – are ready to get back to business. I’m looking forward to CAMX to help us do this and to learn more about some ways to benefit from disruptive innovation ideas. I look forward to seeing you there.

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ODiSI: Advanced Measurements for Composites

ODiSI uses small, nearly weightless fiber optic sensors that can be surface mounted or embedded into the matrix of composite materials for measurement of surface or internal stress, strain and temperature. And now with new real-time data and multichannel capability, ODiSI covers all of your strain and temperature testing needs.

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Composite Molds:
Choices and Considerations

By Rick Pauer and Andrew Pokelwaldt

Composite molds vary widely, depending on the industry and application. For instance, high-end, nickel-iron alloy tooling is commonly used in the aerospace industry, while boat and wind blade manufacturers typically use GFRP molds. This column will focus on traditional composite molds that utilize glass fiber as reinforcement and will provide guidance for manufacturers striving to invest in cost-effective molds that meet the required volume and quality standards, using the best-suited process for manufacturing.

Best practices for mold making vary based on many factors, including the following:

- Number of parts to be made with a mold
- Mold service life
- Cost
- Final product specifications, tolerances and surface finish
- Material selection
- Production rate and delivery deadlines
- Staff expertise

Because there are so many decisions to make concerning molds, we’ve divided the topic into two columns. In this issue, we will discuss the influence of the final product manufacturing process, mold design and plug production. In part two, which will be published in the January/February 2018 issue of Composites Manufacturing magazine, we will examine mold building, mold maintenance and up-and-coming mold innovations.

Composite Production Processes

Prior to starting the mold-making process, it’s imperative to consider the expected production method for the final application. The method you use influences the mold you will build, and, conversely, the mold impacts the production method. Here’s an example illustrating the symbiotic relationship between the two: If you only require a few parts, then you wouldn’t build a mold for a heated resin transfer molding (RTM) process. The mold and process would simply be too costly. But if you plan on fabricating a dozen or so parts per day, then you would likely utilize heated RTM molds, which can turn out two to three parts per hour.

These are some of the factors to consider as you think about both your anticipated production process and the mold:

- **Surface requirements** – The gloss, profile and texture of the final part.
- **Expected volume** – Is the application a prototype (1-5), low volume (20-50), medium (several hundred) or high volume (several thousand)?
- **Number of molds** – Expected volumes determine the number of molds required.
- **Accuracy** – Parts are often joined together, so precision is key.
- **Durability** – This is often tied to required volumes, but simple design modifications (like higher draft angles) can reduce wear and damage of the mold surface.
- **Speed to build** – The time it takes to make one or multiple molds.
- **Cost and budget**

Design, plug making, mold construction, surface preparation, framing, maintenance and demolding can vary significantly depending on what type of composite manufacturing process the mold will ultimately be used for.

Mold Design

The mold-making process typically starts with a plug (a representation of the final part) and the initial mold (the mirror image that is “pulled off” the plug to make production parts). It’s important to start projects off right with a solid design. By investing time, energy and money in the design stage, you can avoid or minimize production issues later. Your return on capital – realized only after production starts – depends on how quickly a high-quality mold can make high-quality parts that require minimal additional input to produce a finished, shippable part.

There are lots of factors that need to be considered during mold design, many of which have already been listed. One primary concern is shrinkage from plug to mold. With older mold-making materials, a rule of thumb was to expect $\frac{1}{32}$-inch

“Your return on capital – realized only after production starts – depends on how quickly a high-quality mold can make high-quality parts that require minimal additional input to produce a finished, shippable part.”

4 Composites Manufacturing
of shrinkage per inch of mold. Part shrinkage related to materials must also be considered in the design stage. With newer controlled-shrink mold-making materials, shrinkage can be minimized, but parts made with shrinking materials still need to be compensated for.

When designing plugs and molds, manufacturers also need to consider things like ease of gel coating, fiber placement, core placement, movement and storage at the plant and their impact on labor costs. Poorly planned designs will lead to build issues for manufacturing. Staff who oversee mold loading, mold care, mold prep, mold movement, demolding and production controls should be consulted during the design phase if production issues and mold durability/life expectancy are of any concern.

There are many software packages available to design plugs via computer aided design (CAD) files and then machine them, including SOLIDWORKS®, Autodesk™, NX for Design and ESAComp.

**Plug Production**

The plug can be designed using various materials, including plaster, foam, wood, tooling board, plastics and modified fiberglass parts. In addition to CAD design, machining and 3-D printing, plugs are often still made by hand, using wood products like medium density fiberboard (MDF) with fairing materials and coatings that are then sanded to the required surface finish. This is a common plug-making method for simple and smaller shapes.

As stated earlier, the production manufacturing process of the final parts significantly influences plug and mold-making decisions. Traditional open molding molds usually provide the lowest cost entry because you only need to build a single mold – generally called the A-side – which gets you to part production faster. Closed molding processes can offer improved back side surfaces, especially when a rigid counter-mold (RTM or light RTM) is built off of the A-side mold.

RTM offers many benefits, including improved dimensional control (part thickness), better resin-to-fiber ratio, reduced void content, cleaner working conditions and reduced emissions during part production. However, there are significant additional costs in making two molds instead of one. Further, the required flange detail, vacuum seals and various ports for resin and vacuum also increase the costs and time associated with building RTM and light RTM counter-molds. Those costs generally are negated by process and production improvements.

Another closed molding option is vacuum infusion processing (VIP). VIP has the lowest entry point costs for closed molding, but it is likely the most expensive process in the long term because VIP is inherently tied to a plethora of disposable materials, such as film, peel ply, resin feed lines, vacuum feed lines and sealant tape. However, VIP only requires building one mold. In addition, the process is very forgiving in laminate and core modifications as the film allows for those modifications.

The guidance above certainly doesn't cover all the complexities of mold design and plug production. Every mold-building project is nuanced and presents different challenges. It's important that composite manufacturers keep up to date on new technologies and materials that can lower costs and increase capabilities. Check out our column in the next issue for information on some of the latest advancements in mold making.

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When the Frank J. Manning Apartments in Cambridge, Mass., were built in 1976 using a cast concrete plank system, the construction style was efficient and cost effective. But more than 40 years later, the style is obsolete, according to the Cambridge Housing Authority (CHA), which manages the 19-story building for elderly and disabled residents. In 2015, the CHA launched a $58 million renovation project to update the façade, core systems, apartment interior and common spaces.

“A lot of public housing units in the country are well over 30 years old, beyond the usable life cycle for many things inside those apartments,” says Megan Multanen, senior sales officer for Bestbath, a manufacturer of composite bathing products in Caldwell, Idaho. “While housing authorities could build new apartments, that’s expensive and time-consuming. Renovation is key to maintaining public housing that is safe and decent.”

Bestbath worked hand-in-hand with CHA, project architect Bargmann-Hendrie + Archetype Inc. and contractor Shawmut Design and Construction on bathroom renovations for all 199 units in the Manning Apartments. The manufacturer provided showers and accompanying components, including domes above the shower, soffit walls and duct covers.

The CHA had three main priorities for the shower renovations: updating the look, ensuring they were easy to clean and maintaining air quality in the bathrooms. “There was a big concern about preventing mold and making sure the bathroom was a healthy space with good air quality,” says Multanen. “In bathrooms, the ability to quickly, easily and effectively clean surfaces is important.” That made Bestbath’s products a good choice for the project.

The company, which has done other projects with the CHA, worked with the design team and engineers on specifications for the showers. Bestbath then took the engineered drawings and built a custom mold for the showers.
Afterward, it fabricated and delivered the showers based on the contractor’s construction schedule – one floor of the high-rise building at a time. Bestbath shipped the first load in June 2016 and the last one in November 2017.

Bestbath is an open mold, spray-up facility. The laminate schedule for the apartment showers included five layers. First, technicians sprayed on a gel coat consisting of a polyester resin and additives to enhance its properties and color. After the gel coat was cured with a methyl ethyl ketone peroxide (MEKP) initiator, the technicians added a proprietary barrier coat to improve the sheen of the gel coat and enhance durability. The barrier coat also was cured with a MEKP initiator. Next, they sprayed on E-glass fibers, rolled out any air bubbles and added a layer of plywood, fully backing the shower wall. Finally, the technicians added another layer of GFRP to encapsulate the wood and cure the product.

The addition of the plywood core is critical for a few reasons, says Multanen. First, it acts as a heavy-duty stiffener. “A resident isn’t going to stand in the shower, push against the wall and be able to flex it,” says Multanen. In addition, the integral wood backing allows property owners to easily add universal design features, such as grab bars and seats, without searching for studs. Finally, the core provides noise reduction from the drumming of water spray on the shower walls and sound insulation from adjacent bathrooms, an important feature in multi-family housing.

According to Multanen, there were three primary challenges associated with the renovation. First, high-rise buildings include fire chases – fire-rated shaft enclosures designed to limit the spread of fire from unit to unit. In the Manning Apartments, the fire chase is in close proximity to the wet wall, behind which the bathroom plumbing is located. Bestbath consulted with the architect and design team to ensure the plumbing didn’t penetrate the fire chase. The manufacturer created a special mold for a four-inch inset, directly behind the shower wall, to contain the plumbing.

The second challenge concerned the concrete slab. “We had to carefully position the shower drains to avoid hitting all of the additional reinforcement in the slab building,” says Multanen. “Obviously, the CHA didn’t want 199 unique showers. So we worked to find a universal drain position that would avoid the reinforcing in the concrete and still allow for a barrier-free entry.” The 60-inch shower opening is nearly even with the bathroom floor for accessibility for disabled residents.

Finally, the heating and exhaust ducts run directly over the shower. The ducts needed to be covered, but remain accessible for maintenance. Bestbath fabricated a composite shower dome with a recessed maintenance access panel.

Design details were decided upon well in advance, with input from everyone involved. “Our engineering team worked closely with the project engineers because we are the composites experts and they know the mechanics of the building,” says Multanen. This kind of teamwork is common in architecture products. In addition to working with engineers, Bestbath also partners with architects to ensure its products meet specific code requirements. “Our sales reps are bathing code experts and can help architects really refine what they need and want in projects,” says Multanen. The company’s products are often specified by architects and engineers.

The combination of quality materials,
A Bestbath employee packages shower wall pieces and accessories for shipment.

an exacting manufacturing process and collaboration with clients is a success. “Our showers are meant to take a beating. They go into high-use environments, like public housing and college dormitories,” says Multanen. “So we want our products to be not only attractive, but durable.”

The showers in the Frank J. Manning Apartments achieve both goals, truly representing the pinnacle of engineered composite solutions.

Susan Keen Flynn is managing editor of Composites Manufacturing magazine. Email comments to sflynn@keenconcepts.net.

For more stories like this, visit CompositesManufacturingMagazine.com and check out the Architecture articles under the “Market Segments” tab.

Megan Multanen of Bestbath will share details of the Frank J. Manning Apartments renovation at a CAMX educational session on Tuesday, Dec. 12, at 9 a.m. Mark your calendars to attend the session, entitled “Enhancing Performance with Composites: Think Outside the Shower.”
For the past few years, Bothell, Wash.-based Global Fiberglass Solutions Inc. (GFSI) has succeeded in taking GFRP wind turbine blades and recycling them into new products like manhole covers and building walkways. In less than 10 years of existence, GFSI has already built an impressive clientele featuring some of the biggest names in wind energy, including GE. According to a June 2017 report from GE, GFSI has recycled 564 blades for them in less than a year. By using GFSI’s recycling process, GE could reuse 50 million pounds of waste in the next couple of years.

As the report explains, GFSI’s recycling process begins at a wind farm, where technicians cut blades into 18.5-meter chunks. To avoid hazardous dust, GFSI uses wet wire blades that are thin and strong enough to slice open each wind blade. The company then sprays a little bit of water on each blade so that the debris goes into a giant dustpan.

Next, GFSI loads the dismantled blades onto flatbed trucks and hauls them to nearby yards where the blades are shredded into raw fiberglass material known as feedback. GFSI is able to reuse 100 percent of each blade with a patented formula that turns the crushed fiberglass into innovative products made of fiberglass mixed with rock and filler. At no point does GFSI attempt to liberate the entire glass fiber from the composite blade.

“You can’t add a bunch of chemicals to something that is basically garbage and make it economically viable,” says Dr. Karl Englund, an associate professor at Washington State University with expertise in composite recycling. “You have to keep it simple.”

According to Don Lilly, GFSI’s president and CEO, the company’s mode of waste transportation is far more cost effective than transporting blades to a landfill. While OEMs and wind farms are charged $15 to $22 per mile in transportation, dumping and tipping fees, GFSI only charges half that price.

“In essence, that was the start of [the business] because what we figured out right then and there, the cost of doing business is a profit up front,” Lilly says. Although the market was open for GFSI when it went into business in 2009, the company was not immediately focused on profit. As GE explains, there were a number of technical details, such as the percentage of fibers from each wind turbine blade that would go into each individual product, which GFSI had to figure out to perfect the science behind the recycling.

To answer those questions, Englund helped GFSI test panels to see if the material science behind its recycling process was sound. The team compared three types of panels side by side: a wood composite oriented strand board, a wooden panelboard and GFSI’s recycled fiberglass panel. In the GE report,
Englund said GFSI’s panels showed better water resistance, mechanical properties, resistance to bio-deterioration and fire resistance than both wood panels.

In addition to a materially sound process, GFSI has distinguished itself from competitors by using an innovative software known as Blade Tracker. The software is designed to help capture the end-of-life cycles of the blades themselves by identifying the exact section of a wind turbine blade being recycled, along with its resin type, glass fiber type, shape and more.

That’s something Lilly and Englund believe many OEMs don’t know how to do.

“Knowledge is everything,” says Englund. “The more we know, the more we can accommodate into the final recycling process.”

To give OEMs an added incentive to recycle with GFSI’s system, Lilly reached out to the Environmental Protection Agency (EPA), which made GFSI a part of its WasteWise program. The program encourages organizations and businesses to achieve sustainability in their practices and reduce industrial waste.

By using the Blade Tracker software, GFSI is able to provide OEMs with a “certificate of decommissioning” once their blades have been recycled, and then submit the composite waste information back to the EPA. The EPA, in turn, assigns the OEM or wind farm a “WasteWise Endorser” certificate, which signifies that the end-of-life blades have been recycled and used to make sustainable products.

Today, Lilly says, GFSI’s process has been refined to the point where it can take a full-size turbine blade, get it off the farm and fully recycled in less than 20 minutes. When the recycling process is finished, a customer like GE can buy back its old wind blades as new products. In 20 years, those recycled products will wear out. But according to Lilly, that presents a unique opportunity.

“If I give you my product today … I’m going to do one thing that most companies don’t do,” Lilly says. “I’m going to ask you ‘Can I have it back?’ Because I can take the same material and reuse it again.”

According to Lilly, companies all around the world are happy to oblige. Three of the four biggest wind manufacturers in China have contacted GFSI about keeping fiberglass out of landfills. “I’m really surprised actually how much of the initiative they are trying to push with regards to the environmental side of it,” Lilly says. “That’s an interesting uptick we never expected from China.”

Englund says GFSI’s success opens the door to opportunities to recycle many other products that feature FRP. He calls wind turbine blades “the low hanging fruit.”

“Maybe the same processing platform won’t work for other types of fiberglass material,” Englund says. “Maybe it will work. We’re just going to have to research to figure out how we can continue this movement.”

Evan Milberg is communications coordinator for ACMA. E-mail comments to emilberg@acmanet.org.

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The Disrupter: The Fast RTM System

Broader Implications: The potential to mass produce structural composite automotive parts.

One of the biggest hurdles to widespread use of composites in automotive production is productivity rates. A consortium of industry partners has developed an automated process capable of producing composite structural parts in a two-minute cycle time, a critical industry metric.

The consortium is led by a French institute, IRT M2P (The Institutes of Technological Research – Materials, Metallurgy and Processes). The long list of partners is evidence that collaboration is key to success in today’s highly complex world, with each one bringing specific expertise to the table: PINETTE P.E.I (press system and platform integration), Arkema and Hexion (resins), Chomarat (reinforcement materials), Compose (tooling), SISE (thermoregulation systems) and the Institut de Soudure (closed mold process). The project also received support from OEM partners and Tier 1 suppliers Renault, Faurecia and Hutchinson, which provided integration and design expertise.

“These companies represent the whole composite sector – material suppliers, equipment suppliers, composites experts and end users,” says Maxime Kowalski, composites activities manager at IRT M2P. “The whole consortium worked together to provide the solutions that would make the project a success.”

The goal of the consortium, which began its work in 2013, was to develop an industrial-scale platform capable of producing net shape, functional, structural parts up to 3 m² (more than 32 square feet). At the heart of the system – called Fast RTM – is PINETTE’s ECS-PRESS (Eco, Compact, Sustainable). The short-stroke press has two six-axis robots for material handling and allows for compression resin transfer molding (C-RTM) – essentially a combination of compression molding and resin transfer molding.

A preform is placed in the open mold cavity, which is then partially closed. Next, resin is injected into the mold gap at low cavity pressure, thereby partially saturating the preform with resin. Afterward, the mold is completely closed and a compression stroke presses the resin through the preform, completely saturating it. The platform is compatible with both thermoset and thermoplastic resins.

“The platform produces a better and faster impregnation of the part than with RTM and makes the process flexible and adaptable to the needs of car manufacturers,” says Kowalsky. In addition to automated loading and unloading, the Fast RTM system is fully instrumented with automatic data acquisition, process parameters traceability, energy consumption measurement systems and online, nondestructive control systems.

Kowalsky says now that the platform “has proven the feasibility and reliability of the production of large and complex...
parts” in the two-minute cycle time, the system is available for automotive, aerospace, railway and other transportation sectors that require high production rates. In addition, the consortium is now working on the Fast FORM project – a complementary project aimed at developing preforming processes and equipment for low-cost, fast cycle time production.

The Disrupter: Wind Blade Prototype

Broader Implications: The possibility to quickly produce blades that are stronger, cheaper and more energy efficient.

Last winter, IACMI – The Composites Institute unveiled a wind blade prototype that’s small in size – only nine meters long – but has big potential to transform the wind energy market. IACMI led a team of industrial and government partners who worked together to fabricate an advanced technology wind turbine blade featuring several innovations, including continuous fiber reinforced thermoplastic parts and exterior shell components produced with less than half of the normal carbon dioxide emissions.

“The work we are doing today will possibly revolutionize the industry five or 10 years down the road,” said Derek Berry, IACMI Wind Technology Area Director, in a YouTube video about the project. “Companies like GE Wind and Siemens and Vestas are looking at the technology we are working on to help them bring down the cost of wind energy, to build more efficient blades in the future and thus be more competitive in the marketplace with wind energy.”

The prototype blade, which is based on designs from previous work conducted the Department of Energy, has the geometric features of a megawatt-size blade that might be 30 to 50 meters long. It utilizes several material and manufacturing innovations, including a thermoplastic resin system.

The blade shells and shear web were infused with Arkema’s Elium® reactive thermoplastic resin system, a liquid resin that’s processed like a thermoset, but cures at room temperature. According to Berry, the prototype was the first blade produced in the U.S. using a thermoplastic resin system. The resin speeds up production. For example, the team did the shear web infusion using the Elium 188 system and got a wet-out of the entire part in about 30 minutes. The shear web was demolded and had its full-strength properties in only three hours – much faster than thermoset materials, according to the YouTube video.

Another innovation is specialized sizing – a coating on the fiberglass itself – that is fully compatible with the resin system. The sizing, provided by Johns Manville, helps ensure that the resin and fibers work well together and that the load transfers to the reinforcement so the composite doesn’t fail at the interface.

In addition, the blade features a pultruded spar cap produced by Strongwell that uses Oak Ridge National Laboratory’s low-cost carbon fiber combined with Huntsman’s polyurethane resins. “The larger and longer the blade gets, the more it needs very stiff materials and carbon fiber becomes a more attractive material,” said Berry. The blade also incorporates recycled PET foam from Creative Foam as a core material, so there’s post-consumer material in the blade itself.

Other partners on the project include TPI Composites Inc.,
DowAksa USA, Chomarat USA, Composites One, SikaAkson and Chem-Trend. The prototype is just the start of the group’s work, said Berry. “We’re showing what we can do, but we have a lot more work to do,” he said. “Our ultimate goal is to commercialize this technology.”

**The Disrupter:** NASA’s Structural Carbon Nanotubes

**Broader Implications:** The potential to save weight, reduce mass and improve performance in aerostructures.

In the aerospace industry, composite nanotechnology has long been a topic of great interest. In 2012, a study from the U.S. Army Corps of Engineers showed that it is possible to develop carbon nanotube fibers with tensile strengths as high as 60 Gigapascals (GPa) – which is more than 10 times as high as conventional intermediate modulus carbon fibers. Other NASA analyses have shown that composites using carbon nanotube reinforcements could lead to a 30 percent reduction in the total mass of a launch vehicle.

Earlier this year, a composite overwrapped pressure vessel (COPV) on a payload in NASA’s SubTec-7 mission flight became the first structural component made with carbon nanotubes flight tested by NASA. To industry outsiders, this raised an interesting question: If composite nanotubes are so strong, what was holding NASA back from flight testing them in a structural component? According to Mike Meador, program element manager for lightweight materials and manufacturing at NASA’s Glenn Research Center in Cleveland, the answer is that historically, carbon nanotubes have not been available for testing in “useful formats” like fabrics or fibers.

That was, until Merrimack, N.H.-based manufacturer Nanocomp started producing carbon nanotube-based yarns and fibers on a large enough scale to be incorporated in a structural application. Meador says his team at NASA worked with Nanocomp to tailor the mechanical and tensile properties of Nanocomp’s products, which could act as a drop-in replacement for components made with traditional CFRP.

The team opted to use a modified filament winding process that involved lining the outside of the COPV with the nanotube-based fibers because the diameter of the fibers was so much smaller than conventional carbon fibers. A COPV, Meador says, is dominated by tensile properties and would therefore be a good demonstration of the nanotubes’ potential.

Meador says his team was able to achieve its main goal of the flight test, which was to use the carbon nanotube-based COPV as a “gas storage bottle” for a cold gas structure system. “[The COPV] did exactly what we expected it to do,” Meador says.

NASA is currently doing post-flight testing to assess whether the flight had any impact on the mechanical properties of the
COPV. So far, the biggest thing Meador has been surprised by is that conventional carbon fiber composites “behave according to the rule of mixtures,” whereas carbon nanotube composites do not. “We found that the strength of the [nanotube] composite was actually better than the strength of the fiber reinforcement, and that’s not what you see in conventional carbon fibers,” Meador says.

The Disrupter: R3FIBER Recycling Technology
Broader Implications: The potential to recover and reuse fibers from end-of-life composites.

There’s a big push within the composites industry to develop scalable recycling methodologies. One of the solutions that’s received lots of press is Thermolyzer™ technology from CHZ Technologies, which you can read about online at www.compositesmanufacturingmagazine.com. But other companies are working on composite recycling, too, including a start-up whose name says it all – Thermal Recycling of Composites (TRC).

TRC created the R3FIBER technology to recycle wind turbine blades and other composites at the end of their serviceable lives and obtain high-quality fibers, energy and fuels. “We’ve focused on recycling of composites due to the huge quantity of waste that’s already been dumped into landfills and because of the growing use of [FRP] materials, which are increasing nine to 12 percent every year,” says Oriol Grau, CEO of the Barcelona-based company.

Grau and a team from the Spanish National Research Council’s National Center for Metallurgical Research began developing R3FIBER in 2008, built a pilot plant in 2014 and officially launched TRC last year. They are currently designing a pre-industrial plant with 100 tons of nominal capacity, with plans to build the facility in 2018.

R3FIBER utilizes a thermochemical process that converts the resins of combustible gases and liquid fuels into high-quality glass or carbon fibers that can be reused and retain 70 to 90 percent of the mechanical properties of virgin fibers, says Grau. The process can be used on both GFRP and CFRP with different resins, primarily epoxy and phenolic. “Afterward, the fibers can be used to manufacture new composites, and the fuel obtained during the process can be revalorized into the market,” says Grau.

Grau didn’t share further details of TRC’s patented recycling process. However, the company has signed agreements with strategic collaborators, including EDP Renewables (EDPR), one of the world’s largest wind energy producers. EDPR and TRC...
will work together to recycle damaged and end-of-life wind turbine blades. TRC also is part of Climate-KIC, a public-private partnership created by the European Institute of Innovation and Technology to focus on climate change and create economically-viable products to mitigate climate change.

While R3FIBER is in the scale-up phase now, TRC hopes to commercialize the technology. TRC also is developing new materials and products made of recycled fibers. Grau says his company could provide a viable solution for composites manufacturers, consumers and the environment. “Thanks to our technology, cheaper and more environmentally-friendly fibers will be available,” he says.

The Disrupter: Composite Exosuit
Broader Implications: Human assistive devices could increase productivity, efficiency and safety.

In recent years, a popular research trend is the idea of science inspired by science fiction. One retail giant, home improvement company Lowe’s, created a laboratory it says uses “narrative-driven innovation” to create new technologies to “disrupt the future.” Earlier this year, Lowe’s Innovation Labs teamed up with Alan Asbeck, an assistant professor in the Department of Mechanical Engineering at Virginia Tech, to create a superhero-inspired exosuit designed to help employees lift and move items through the store more efficiently.

The exosuit features unidirectional, prepreg CFRP beams that go behind an employee’s legs, with CFRP straps around the thighs that connect to the beams. The exosuits also incorporate CFRP straps, like a backpack, for an employee’s shoulders, and a belt across the middle to connect the shoulder straps.

As Asbeck explains, the suit works like a giant bow and arrow. As an employee bends down to pick up something, their body falls forward under the influence of gravity. The downward motion of the torso loads up the carbon fiber into what Asbeck calls a “curved C shape,” like pulling on the string of a bow and arrow. When this happens, the energy in the person’s body is transferred to the exosuit and is stored there until the person stands back up.

“And then when you go to stand back up, it pulls up on your body, on your torso, and basically brings you back into an upright position,” Asbeck explains.

During the research process to develop the exosuit prototype, Asbeck’s team explored several material options to store kinetic energy. They started with steel springs, but soon realized that in order to effectively store energy, they would need an inordinately large and heavy spring. Employing CFRP, on the other hand, meant the team could use less material. Asbeck adds that carbon fiber can bend very well and has “sort of a loose spring construction,” meaning you can fit it right next to the body and it doesn’t outwardly protrude very much.

“You’d have to wear it around all day, so you want it to be as light as possible,” Asbeck says. “You don’t want [the exosuit] to stick out a lot because then you’d be bumping into things as you walk around or maybe you wouldn’t be able to fit in a narrow aisle.”

For the next version of the exosuit, Asbeck says the goal is to drive down production costs so he is considering using GFRP.

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Innovation on Display at CAMX

On Tuesday, Dec. 12., in Orlando, Fla., at the CAMX General Session, winners of the prestigious Combined Strength Award and Unsurpassed Innovation Award will be announced. Later in the day, the Awards for Composites Excellence (ACE) will be presented. The awards recognize innovations that have the potential to significantly impact composites and advanced materials. This year, IACMI is a finalist for the Combined Strength Award for its 9-meter turbine blade. See the blade and other innovations in the CAMX Exhibit Hall!
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There's little doubt that composite components are going to play a major role in shaping the future of the automotive industry. Between federal mandates to lower fuel consumption and expanded use of composites in commercial trucking and similar industries, it seems inevitable. Experts have predicted that the wide-scale manufacture of composite-intensive vehicles will become the norm in the next five years. But they've been singing that tune for at least six years now.

In 2011 when BMW unveiled its all-electric i3 car, with its comprehensive specification of composite parts including a CFRP passenger cell, there was a sense that the use of composite components would leap forward. Finally automotive designers and engineers would have the evidence they needed to confidently design future iterations of composite-laden automobiles.

And now? “The timeframe for penetration of composites in the automotive market seems to be moving out,” says Terrence J. O’Donovan, vice president of marketing and sales for Core Molding Technologies Inc. and chair of ACMA’s Automotive Composites Alliance (ACA).

Many composites experts looking to gain a bigger chunk of the automotive market agree that the 5-year forecast for more explosive use of fiber-based materials didn’t exactly hold true. But these experts add that this moving target doesn’t make the automotive market any less promising – and the forecasts may not be far off.

**Lightweighting is Part of a Bigger Puzzle**

The majority of the respondents to a 2017 survey on the federal government’s Corporate Average Fuel Economy (CAFE) standards, sponsored by DuPont with Ward’s Auto and conducted by Penton Market Research, indicated that lightweighting is still considered the best solution for meeting the 2025 fuel efficiency standards. The majority of the nearly 750 surveyed professionals in automotive design, manufacture or component supply indicated that improvements to lightweighting through the use of lighter structural materials remains the best way to achieve the fuel reduction necessary. Additionally, 44 percent of survey respondents indicated that powertrain and chassis are the top two vehicle systems that automakers are targeting for weight reductions.

Composite materials are still seen as a leading material in terms of meeting these lightweighting expectations. Solutions like Core Molding Technologies’ lower-density sheet molding compounds (SMCs) achieve new strides in lightweighting. The company now has a full range of SMC systems at a 1.2 specific gravity, which O’Donovan says has become the new de facto standard for low-density composites. More specifically Hydralite®, with its 0.98 specific gravity, takes the density of sheet molding thermosets below the range of thermoplastics and below the density of water. “We have developed material systems and innovative manufacturing methods that have found application in underbody shields and electric vehicle battery covers,” O’Donovan adds.

However, fuel efficiency improvements are simply one requirement that manufacturers are striving to meet. “Requirements like heat, crash worthiness and others are increasing and require properties greater than just being lightweight,” points out Keith Bihary, corporate sales director for Molded Fiber Glass Companies. And in those areas, composites face tough competition from competitive materials that have a much greater stake in this industry.

Composite suppliers are quick to point out that steel and aluminum have a significant head start when it comes to demonstrated performance. “Compared to its metal competitors, automotive composites is a ‘baby’ material system at about 60 to 70 years old,” says O’Donovan. And while it will ultimately take time for automotive designers and engineers to gain the necessary comfort in composites’ performance, there’s no room for suppliers to sit and wait for the automotive industry to embrace the promise of these materials.

“While composites have advanced – and continue to do so – so have the competing material systems: advanced high strength steel and aluminum,” O’Donovan says. “In particular, aluminum has emerged as the winning material (to displace steel for weight savings) in many of the current generation of vehicles.”

Bihary agrees. “The competitive materials are not sitting on the sidelines silently,” he says. “They are constantly making improvements and lobbying to retain their presence on the vehicles.”

This makes it more important than ever for the composite industry to drive the changes that need to happen in terms of cost and manufacturing efficiency if suppliers truly want to gain a larger part of this market’s business.

**Hitting Cost and Manufacturing Goals**

Cost and production efficiency remain among the most significant obstacles for the industry to address. “Aerospace carbon prices are dominating the market, so although you’re
getting significantly higher performance, the cost remains a barrier,” points out Uday Vaidya, chief technology officer of IACMI – The Composites Institute.

Material end users need education about alternatives to aerospace-grade materials, as this can make carbon fiber a much more attractive option for wide-scale applications. They also need reminders that the cost of carbon fiber has decreased. “The cost of carbon fiber, still relatively high, has been reduced by factors of two to three times in recent years,” says O’Donovan. “Many projects are underway to drive the cost down even further.”

Philip Schell, executive vice president of carbon fiber for Zoltek Corp., adds that when it comes to cost-effectively incorporating carbon fiber, cost is driven down by using the most efficient manufacturing processes. “Processes that efficiently use the material and transfer greater than 95 percent of that material into the final part are going to have some advantages,” he says.

Thermoplastic processes may be more likely to find greater use in this industry over fabric-based or prepreg systems where as much as 15 percent of the continuous fiber may not make it into the final part.

Then of course there’s the issue of production time. Large-scale production has always been a problem for composites based on the extended cycle times compared to more traditional materials. But improvements are being made.

For example, O’Donovan says, resin companies are working to improve resin and catalyst formulations that can drive cure times down to single-digit minutes, allowing composite cycle times to approach those of steel and aluminum.

While improvements have been made here, Bihary notes that consistency in manufacturing also has to be up to the task. “I think those challenges are being met but that also needs to be proven to give the OEMs a comfort factor,” he says.

“While composite parts are consistently lighter, stronger and more durable than the metal materials used today, the rate of manufacture and overall cost does not yet convince most OEMs to implement a move to composite materials,” agrees Chris Mikesell, sales manager for Chomarat North America. And this is a demand that requires not necessarily an adjustment to manufacturing, but to positioning. Mikesell adds, “Our industry needs to be smart as to how we present what can eventually become wholesale changes to the way we design and build cars.”

### Exploring Combinations and Collaborations

In this regard, it could be most beneficial for the composites industry to harness the benefits of competing materials by focusing on areas where composites can be blended with or connected to other materials.

Ed Pilpel, senior advisor at PolyOne Advanced Composites, points to strategies European manufacturers have used to commercialize thermoplastic composites on a large scale. “The Europeans have done a lot of development in selective reinforcements in injection molding, and it’s now coming to the United States,” he says. “If you look at some of those companies that do injection molding, [many] now incorporate continuous fiber thermoplastic reinforcements into the injection mold to gain strength and stiffness.”

In the automotive industry, blends with more traditional materials help to provide designers and engineers with some familiar properties for testing. “We’re seeing examples of hybrids where they make parts of the car out of thinner gauge metal, such as steel or aluminum, and then stiffen or strengthen that with a carbon composite,” Schell says. “That way we’re getting a good portion of the lightweighting, but minimizing the total part cost.”

For example, Chomarat’s C-PLY™ essentially formats carbon tow into a pre-specified weight and direction. The C-PLY is then stitched together creating a ‘stack’ of angled carbon fiber. “The C-PLY construction can eliminate angles that are not necessary for part integrity, focusing solely on where the fiber needs to be. This eliminates cost and waste while helping to create a stronger part,” Mikesell explains.

Moreover, C-PLY can incorporate mixed materials within this carbon stack. “The ability to put materials like thermoplastics, aramids and toughening veils in between plies can enhance overall properties and move these materials closer to a finished part,” Mikesell adds. The end result is being used today in wheel assemblies, among other applications.

In addition, O’Donovan notes, new fastening methods have been developed that are capable of joining composites to metals, and this technology can help further this integration of materials.

But the industry might be aided not simply by working better with other materials – but also working better with each other and leading industry groups. Chomarat partners with many consortiums, including IACMI, the United States Council for Automotive Research (USCAR) and Stamping Technology for Automotive Manufacturing Processing of Composites (STAMP). “These groups can give Chomarat access to other companies with technologies that are vital to presenting overall product solutions
to the automotive industry,” says Mikesell. “These collaborations will be what reins in that moving target.”

In fact, this may be an area where composites have a distinct advantage. “The metal counterparts are for the most part supported by a single raw material supplier and a single part manufacturer,” O’Donovan points out. “Composites involve cooperation among resin, fiber, additive, molder and often secondary and assembly suppliers, all working together to achieve a predictable result that an automotive OEM can be confident can be replicated around the world.”

**Passing the Biggest Test**

The biggest disadvantage that composites still have to overcome is simply the lack of proven performance in specific automotive applications. It’s a challenge that can only be overcome by time—and good data.

“Data, data, data is the way to convince OEMs that the materials are up to the task, not only in small lab batch trials but also in large-scale production,” Bihary says. “As that data base grows, more engineers become comfortable designing with it.”

O’Donovan notes that research is presently underway to characterize composite properties and feed that data into computer design databases and software that can model performance. This research is aimed at creating methods to characterize damage that might occur during automobile use and to develop reliable repair methods. “Composites are highly tailorable in their applications, yet are generally anisotropic and non-homogenous, making it more difficult for engineers to evaluate performance under dynamic load conditions,” he adds.

Pilpel notes that the industry now has access to a resource that wasn’t there five years ago. He points to the Composites Manufacturing & Simulation Center, launched in 2015 at Purdue University, as a game-changer. “One of the challenges we face is the education of engineers and designers on not only how to design with composites but also how to manufacture with it like they already do with aluminum and steel,” Pilpel says. “I think that problem will now be solved with the Simulation Center.”

Despite the challenges, suppliers with stakes in the automotive market see a bright future for composites in automotive applications.

“The hurdles are steep for composites, but so are the future fuel economy expectations. Thus, the reward for expanding use of composites in automotive applications will be high, and the future of the industry should be bright,” O’Donovan says. Given that automotive products generally see design generation cycles of approximately five years, the industry is looking to the next phase of development. It’s there that composites can advance their place in the lightweight materials race—knowing that competitive materials are advancing as well.

Given the work currently underway, composites experts predict that it won’t be long before more composite-intensive components are integrated into mainstream cars. “Many of the IACMI projects are looking at 2020,” Vaidya says.

The five-year projection may have been ambitious several years ago, but we’re now well on our way toward making it a realistic goal.

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By Mary Lou Jay

The 3-D composites additive manufacturing industry is experiencing steady growth, spurred by the flexibility, speed and lower cost that the technology can offer. SmarTech Publishing, which specializes in 3-D printing industry research and data, is bullish on the market, forecasting total revenues for composites additive manufacturing reaching $580 million by 2026.

As the use of 3-D printing technology becomes more widespread, manufacturers are finding innovative ways to use it. Here’s a look at what four companies are doing.

Driving Innovation

Penske Racing has understood the benefits of additive technology for over a decade. It began with stereolithography (SLA) 3-D printers to scale model parts for wind tunnel testing for NASCAR and IndyCar vehicles. Over the years, Penske has expanded its 3-D printing capabilities, enabling the company to better tailor the properties of the printed products to specific applications.

Penske uses specific resin systems with SLA that produce the desired stiffness for wind tunnel models, but result in parts that are often brittle. Printed components such as mockups, jigs and fixtures can’t suffer from this brittle characteristic. Partnering with Stratasys, Penske brought in a fused deposition modeling (FDM) printer, which extrudes polymers layer by layer.

From automotive and aerospace to biomedical and building, more industries are discovering the versatility of additive manufacturing.
“The FDM materials are more durable compared to our SLA resins. Prototype, jig and fixture parts can be mocked up, bolted and dropped without breaking,” says Andrew Miller, composite engineer at Penske Racing. The FDM technology filled a void in Penske’s additive manufacturing program, enabling the company to produce jigs and tooling faster for improved on-track performance.

Penske uses many FDM materials for its applications, including durable and chemical-resistant Nylon 12 for jigs and fixtures and temperature-resistant ULTEM™ 1010 for composite tooling. “With our composite tooling, in some cases we are curing components under high temperature and pressure – 90 psi, 250 degrees F – so we use ULTEM 1010, which has really high strength and temperature capability,” says Miller.

Furthermore, the FDM printer has freed up machine shop resources. “We are able to print our tools and patterns much quicker than we could traditionally machine them, especially parts that would involve five-axis machining, which gets to be expensive and time consuming,” say Miller.

Using the FDM printer, Penske recently produced a fuel probe handle and housing for IndyCar teams. A mechanic who fuels up a car at a pit stop uses a large probe with a handle assembly that alerts him with sensors and lights when the tank is full. Previously made from fabricated aluminum, the handle was heavy and not well integrated into the probe. Penske engineers designed a lighter and better integrated composite handle for the Indy 500, but the turnaround time was tight and there were challenges in making the part.

“We came up with a method of using the ULTEM 1010 to print the master pattern tooling, which enabled us to get our tools much quicker,” says Miller. “Since the geometry internals were quite tight, we weren’t going to be able to use the traditional bagging method. One of the other benefits of the FDM technology is that they have some materials that are soluble in a detergent solution. We can laminate the part around a soluble core, and once the part is cured in a solid we can dissolve the core out from the inside.”

With the 3-D technology, Penske met the deadline while saving money. Master patterns built using traditional tooling would have cost $8,500 and taken three to four weeks; with the FDM printer, it cost just $870 and took less than a week.

Penske also uses a selective laser sintering (SLS) printer to produce race car components such as carbon monoxide filters for drivers’ helmets, brackets and wiring housings for vehicle interiors, and exterior parts like brake ducts. They are printed with a low-density carbon fiber-reinforced nylon that provides strength and, when needed, temperature resistance.

To further expand its additive technologies, Penske added a PolyJet printer through its Stratasys partnership. “It’s like a traditional inkjet printer, but instead of printing ink, it’s printing a curable liquid photo polymer that is cured by UV light,” explains Miller. Penske designers will use this machine to produce part mockups, freeing up the SLA machines for steady wind tunnel model part demands.

The PolyJet will also offer unique flexibility in mockup parts design. An inkjet printer has several color cartridges that can combine to create a variety of hues; similarly, the PolyJet cartridges can hold several different polymer systems that can be combined in various ratios for different material properties.

Miller says Penske hopes to see more large-format 3-D printers that can work with continuous fiber reinforcements and materials with higher temperatures in the future and closely monitors that space in the additive industry. “There’s the potential that you could get higher strength and more structurally optimized components with it,” he adds.

**Smoother Sailing**

Daniele Cevola and Francesco Belvisi are co-founders of Livrea Yacht, a yacht design and manufacturing company based in Palermo, Italy. They introduced their first yacht model with 3-D printed parts – the Livrea 26, Born by the Wind – at the Miami Boat Show in 2014. Most of that boat was built using researchers at Oak Ridge National Laboratory used a bamboo biocomposite material to 3-D print two pavilions for the 2016 Design Miami Showcase. The pavilions are a finalist for the Innovation in Green Composites Design award at CAMX 2017.

Researchers at Oak Ridge National Laboratory used a bamboo biocomposite material to 3-D print two pavilions for the 2016 Design Miami Showcase. The pavilions are a finalist for the Innovation in Green Composites Design award at CAMX 2017.
carbon fiber molds and conventional composite manufacturing
techniques, but some small sections were 3-D printed. “Our
partner, the CRP Group, used only sintering 3-D printing
technology, so there were limitations on the size of the parts we
could build,” Cevola explains.

Since that time, the partners have continued to explore design
possibilities that additive manufacturing offers to boat builders.
To produce larger parts, they developed a specialized extruder and
partnered with KUKA Robotics, software provider Autodesk Inc.
and LEHVOSS, a German chemical company that specializes in
high-performance carbon and glass-fiber reinforced polyamide.

One of the big advantages to this printer setup was its six
axes of movement. “The first time we had to put our extruder
in a CNC machine with three axes, x, y and z. But with six axes
we can find a different configuration that can better solve many
problems in the dynamics of the movement of the robots. This
allows for more precision in the part,” says Cevola.

With 3-D printing, Cevola can find different solutions to
boat building challenges. “We want to change the rules for
sailboat and motor boat manufacturing, because right now they
are designed and built the same way they have been built for 50
or 60 years,” he says. “There needs to be more innovation in the
marine industry.”

Boat builders typically produce a wooden model, build
composite molds from these models and then use the molds to
build the hull or other parts with FRP materials. This can be
both expensive and time consuming, Cevola says. “We propose
a new era for the production of boats – building without the production of molds.”

Working with molds is limiting, since you have to respect the “rules” of the mold when designing a boat hull, deck or other component, says Cevola. For example, the part has to be shaped so that it can be successfully extracted from the mold. “With 3-D printing, you can create shapes that enable you to design new functions into your object. You can integrate many different functions when you don’t have to follow the rules of the mold,” says Cevola. “It’s a new vision, a new possibility for design.”

The Livrea Yacht partners have a specific goal in mind as they experiment with manufacturing boats through the 3-D printing process. They intend to enter a 3-D printed yacht in the 2019 Mini Transat, a 4,000-mile solo race that starts in France and ends in South America.

It would be the first 3-D printed boat in history, says Belvisi. “In the Mini Transat project, we are exploring new ways to produce a high-performance boat, thanks to the possibility of integrating multiple functionality and of manufacturing complex and optimized structures that aren’t possible to build in the traditional way.”

Cevola believes that Livrea Yacht’s 3-D printing technology will become available for many shipyards within the next few years, but he thinks boat builders will use it primarily for high-end, custom yachts, much as Porsche, Lamborghini and Ferrari are using 3-D printed parts for their higher end cars.

### Magnetic Reinforcements

Startup 3DFortify has attracted attention with its unique method of fine-tuning the properties of composite products it builds using additive manufacturing. Josh Martin, president and co-founder, notes that injection molders have been reinforcing their composite tools with carbon and glass fibers for years, but 3-D printed tools have not usually included that additional fiber strengthening. Now, using its custom-made 3-D printers, 3DFortify introduces magnetized carbon fiber technology to composite tools.

“Magnetizing the fibers gives us the ability to control their alignment in real time during the additive manufacturing process,” says Martin. As a result, 3DFortify can print very complicated, high-resolution shapes that can be individually fine-tuned to create desired mechanical and thermal properties in different parts of the tool. “We are able to provide highly detailed and also very robust parts. In a lot of other processes, you can get high strength but you usually sacrifice resolution,” adds Martin.

3DFortify’s process dramatically reduces the time required to produce composite parts. One consumer products customer has dozens of items that require short runs of around 1,000 parts. The typical manufacturing process for a conventional tool could take four to six weeks. 3DFortify can make a similar tool in about four to six hours, saving the customer both time and money.

3DFortify uses a light-based stereolithographic 3-D printing process. “It’s been proven to be one of the most scalable 3-D printing methods,” says Martin. To date the company has been able to print tools for injection molding everything from ABS to polycarbonate, and it continues to look for ways to print composite products with tougher and stronger resins that can handle high temperatures. While 3DFortify is now limited to printing tools that are 3 x 4 x 12 inches (in the x, y and z range respectively), the company is moving toward scaling up to print up 12 inches in each direction.

3DFortify is currently concentrating its efforts in the injection molding, aerospace and automotive industries, but Martin says the process will be valuable in the biomedical industry and several other markets that require high-strength, customizable composites.

### Going Green

Researchers at Oak Ridge National Laboratory (ORNL) have been exploring the use of biocomposite materials for additive manufacturing. In 2016, they produced a 3-D printed table made from a bamboo composite. So when SHoP Architects of New York contacted them last summer about using that bamboo material to build sections of two pavilions, researchers were eager to participate. But they were also a little daunted by the task. “We were going to go from a small table to a structure that required 10,000 pounds of material,” says Soydan Ozcan, a senior R&D scientist in composites and additive manufacturing at ORNL.

SHoP won a competition to design two entrance pavilions for the 2016 edition of Design Miami, a yearly showcase for architects and design professionals. The firm tapped Branch Technologies to print the overhead structural trellis/framework for the pavilions – named Flotsam & Jetsam – and asked ORNL to manufacture the support legs, seating areas and counter space.

The entire structure was printed using a 100 percent biobased and biodegradable composite material – a bamboo-fiber reinforced biopolymer formulation, made with 20 percent bamboo and 80 percent polylactic acid (PLA), a biodegradable, thermoplastic polyester.
“Making the material printable is the No. 1 manufacturing challenge,” says Ozcan. “We had to go to the manufacturer to modify the material and adjust it for the layer time. In order to get the needed strength when the two layers are bonded together, the first layer needs to be fully solidified before putting the second one on.” ORNL researchers worked with Sunstrand, which fillibrated the bamboo materials to the correct micro size so they could be used in the composite material.

ORNL researchers also wanted a material that could move through the printer more quickly and was UV-resistant so it could survive the harsh Miami sun.

The laboratory used its Big Area Additive Manufacturing (BAAM) printer to produce the pavilion components. With BAAM, ORNL can manufacture parts up to 20 feet wide, six feet long and eight feet high. The laboratory printed the pieces in about a week working around the clock, processing about 50 pounds of the bamboo composite per hour. Ozcan says the manufacturing process took longer because this was ORNL’s first big structure and they had to work out some kinks in the process. The BAAM machine is capable of nearly double that speed using the biomaterial composite.

The biodegradable bamboo composite has one-third of the embodied energy and a carbon fiber footprint that’s 90 percent less than a comparable carbon fiber composite, Ozcan says. Although it might not offer the same strength properties as carbon fiber, the bamboo composite was more than strong enough for this application, and it offers many other advantages. One of those is cost; bamboo composites are 40 to 50 percent cheaper than carbon fiber composites.

“Bamboo is a very, very renewable material; some species grow more than three feet in a day. When harvested, it will grow new shoots from its extensive roots, so there is no need for additional planting or cultivation, and it also absorbs 35 percent more carbon dioxide per hectare than trees,” says Ozcan. Bamboo can grow in a variety of climates without the use of fertilizer, pesticides or herbicides and, unlike carbon fiber, requires very little energy to produce.

The Flotsam & Jetsam pavilions, the largest “green” structures ever printed, attracted a lot of press attention when Design Miami opened. They were later moved to a more permanent location in the city, where ORNL researchers hope to observe how the material stands up to the hot, humid, salt-laden air. (The pavilion was disassembled and stored prior to Hurricane Irma.)

Ozcan says ORNL is also exploring a variety of other renewable materials, including those made from forest products, for use in additive manufacturing. “Nanocellulose – the next generation reinforcement – is extremely strong, highly stiff and we are trying to find a commercial way of using it for 3-D printing,” he adds.

Using additive manufacturing with locally grown, biocomposite, biodegradable materials opens up a range of possibilities and opportunities for creating local businesses and local jobs, says Ozcan. “I really believe that down the road there will be a rethinking of manufacturing and the growth of the sustainability portion of it.”

Mary Lou Jay is a freelance writer based in Timonium, Md. Email comments to mljay@comcast.net.
Earlier this year, Shane Weyant, president and CEO of Alum Bank, Pa.-based Creative Pultrusions and vice chair of ACMA’s Public Policy Steering Committee, testified before the U.S. House of Representatives’ Energy and Commerce Subcommittee on Digital Commerce and Consumer Protection. During his testimony, Weyant explained how FRP could offer a more efficient use of taxpayer dollars compared to conventional materials. Now that parts of our country have been devastated from two major hurricanes, we caught up with Weyant to learn more about how ACMA is helping shape the national conversation about infrastructure and why it’s time to rebuild with composites.

CM: What message is ACMA sending to Washington about composites in infrastructure?

Weyant: The message we’re trying to send is that our infrastructure has been deteriorating over the past 50 years and needs to be replaced. Congress needs to prioritize infrastructure spending, and our industry is in a position to contribute to our nation’s rebuilding projects with innovative, lightweight, low-maintenance and corrosion-resistant composite materials.

CM: In the September/October 2013 edition of Composites Manufacturing, we highlighted how Creative Pultrusions helped repair parts of Liberty Island in New York after Superstorm Sandy. How aware is Congress about the viability of rebuilding structures with composites after natural disasters – especially in light of Hurricanes Harvey and Irma?

Weyant: A lot of people in Congress do not know our success stories. It is our duty to make sure we spread the news and show that composites have a proven track record when it comes to constructing highway infrastructure, upgrading our nation’s electric grid and rebuilding in the wake of natural disasters. Recently, Creative Pultrusions had an installation eight miles from the eye of Hurricane Irma, consisting of around 30 utility poles, all of which successfully withstood the storm while other wood and concrete structures in that area’s utility grid came down. Many other composites businesses have similar stories to share.

CM: So is a general lack of awareness the biggest obstacle the industry faces?

Weyant: The biggest obstacle right now is a lack of codes and standards for building critical infrastructure with composites. Without those codes and standards, it is difficult for various state departments of transportation, as well as federal agencies like the Federal Highway Administration, to accept composites. At ACMA, we’ve been working on developing these documents for a long time and we need to continue pushing. It’s also very important that we keep a united front. We need to look at traditional materials vying for market share as our competition, not other composites businesses.

CM: Over the past few years, ACMA has been increasingly active in the infrastructure advocacy arena through Infrastructure Day. What’s the next step for the Public Policy Steering Committee?

Weyant: In general, I think our annual Infrastructure Day event is very successful, and I’m excited for the next one in 2018. The next step is to find ways to turn that success into action. We’ve had a great past few years in terms of getting language into legislation like the 2015 transportation bill. Over the next 10 years, government spending to repair deteriorating infrastructure is going to be substantial, so we need to continue our efforts to ensure composites are in the conversation.

“We need to look at traditional materials vying for market share as our competition, not other composites businesses.”
Speaking with One Voice About Composites

Increasing the use and adoption of composites across all market segments is a key goal for ACMA and its members. To help achieve this, the ACMA Marketing and Communications Committee is developing messages and tools for all ACMA members to use when they communicate about the benefits of composites. The goal is to raise awareness of composites with end users, specifiers and designers to ultimately increase the usage of composite materials over other types of materials. The project includes a new composites website, as well as marketing and public relations tools that ACMA members can use in their own outreach. ACMA will also use these messages and tools in its outreach to external stakeholders. Learn more and see the website and tools at CAMX in December. For more information, contact Barbara Sadowy at bsadowy@acmanet.org.

ACMA Calendar of Events

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<tr>
<th>DECEMBER 11-14, 2017</th>
<th>JANUARY 31-FEBRUARY 1, 2018</th>
<th>MARCH 13, 2018</th>
<th>APRIL 10-12, 2018</th>
<th>MAY 1-3, 2018</th>
<th>JUNE 26, 2018</th>
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<tr>
<td>CAMX Orlando, FL</td>
<td>Global Composites Conference Las Vegas, NV</td>
<td>ACMA Face-to-Face Event Houston, TX</td>
<td>Composites Recycling Conference Knoxville, TN</td>
<td>CCT Instructors Course Kansas City, MO</td>
<td>ACMA Face-to-Face Event Dayton, OH</td>
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CAMX 2017 Update: Make Your December Plans Now!

After postponing this year’s CAMX due to Hurricane Irma, the show is now taking place Dec. 11-14, 2017, in Orlando, Fla. The full conference program and list of exhibitors is available at thecamx.org. Registration and housing are also open, so make your plans to attend now!

Safe, Green Acetone Replacement

Approaching our sixth decade in the marketplace, U.S. Polychem Corp. is proud to announce the availability of our Polychem Acrastrip line.

Polychem Acrastrip is a safe, green alternative for all your cleaning needs within the composite industry.

U.S. Polychem has partnered with the EPA’s Design for the Environment (“DfE”) program to promote the use of products with improved environmental and human health characteristics.

Polychem Acrastrip is non-flammable, biodegradable, has no HAPS and is re-usable. Designed as a solvent and acetone replacement product, it will effectively clean, flush and strip uncured or cured polyester, vinyl ester, epoxy resins, as well as adhesives and coatings.

In addition to our Acrastrip line, Polychem has introduced “Bio-Lock,” a revolutionary way to eliminate grinding and sanding for secondary bonding!

Feel free to contact us at www.uspoly.com or 1-800-431-2072
When you think of Aston Martin, you probably picture a high-end sports car zooming down a wide open road. Earlier this year, the OEM diversified by entering the boating market with the AM37 – a luxury yacht that literally features a boatload of composites.

In 2015, Quintessence Yachts, a relatively new U.K.-based company, approached Aston Martin about changing the paradigm of classic yachting with a new and innovative design. That same year, Quintessence was given the license to build the AM37 with help from renowned naval architect Bas Mulder. Aston Martin Chief Creative Officer Marek Reichman and his team were involved in the collaboration as well.

Quintessence believes the collaboration was a great chance for Aston Martin to learn more about composites in highly-detailed marine applications. According to Quintessence, using composites for the AM37 gave the yacht a “healthy power-to-weight ratio,” while making the hull strong, stiff and lightweight.

“Reichman and his team were amazingly open to learning,” a Quintessence spokesperson told Composites Manufacturing. “And that is the core of the collaboration – really understanding where we are coming from, what we want and why we want it.”

Quintessence says it took a holistic approach to the boat's weight distribution and balance, relying on “high-tech composite materials used in the construction of the stepped hull to provide the type of comfort Aston Martin car owners expect.”

The production process for the AM37 deployed state-of-the-art vacuum infusion technology and post curing. As Quintessence explains, vacuum infusion allows full integration of the structure and interior modules.

Aston Martin is treating the boat as an exclusive purchase, as only eight to 12 boats will be sold each year.
CONGRATULATIONS TO THIS YEAR’S ACMA AWARDS RECIPIENTS

These awards recognize the exceptional people who have done their part in making the field of composites a great industry.

**Lifetime Achievement**

**BOB LONG**
Marine Concepts

**Hall of Fame**

**ROB HABERLEIN**
Engineering Environmental

**Outstanding Volunteer**

**ROBERT STEFFEN**
Western Carolina University

COME AND CELEBRATE ACMA’S 2017 MEMBERSHIP AWARDS.

Join us during the Recognition Ceremony and Reception at CAMX on Monday, December 11 from 5:30 to 7:00 p.m. in Orlando, Fla.

Get your ticket to the Ceremony and Reception when you register for CAMX at thecamx.org/registration.
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