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REINFORCING YOUR IDEAS
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About the Cover: Photo of the Carlsbad Desalination Plant courtesy of Ershigs
A Reflection on Customer Relationships

As the holidays approach, many people think about what’s important to them and who they are thankful for. For businesses, one important group stands out – customers. Without a doubt the most important component of each of our businesses is our customers. They are the reason we are in business, and without them we would not exist. While all customers contribute to our success, each of us can probably name a few special clients with whom we’ve created relationships. These top customers take our business to a new level.

This edition of Composites Manufacturing magazine features an article on customer collaboration on page 20. While collaboration can take many forms, for me it really refers to the way an organization uses customer feedback and interaction to benefit its business, products and services for the ultimate benefit of both parties. When you can develop a partnership with a customer, both parties win. Truly listening to your customer and providing feedback will position you ahead of your competitors. Embracing this relationship with a focus on alignment, flexibility and feedback is critical to having a collaborative relationship with customers.

In my experience, when I have been successful in developing a true partnership with a customer, both companies have succeeded in strengthening each other’s business. It is a relationship that provides an opportunity to clearly understand each other’s issues, goals and strategies that leads to a long-term win/win situation. The better we are at collaborating with our customers, as well as our suppliers and other business partners, the more successful we all will be. And that, in turn, will strengthen the composites industry as a whole.

Thank you for your support of ACMA, another shining example of how collaboration makes us stronger. Together, we will thrive! Our organization is doing great things for our industry, and it is wonderful to be a part of it. Enjoy your holidays, and take time to reflect on and be thankful for all the partnerships in your life.

Jeff Craney
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Proper Tooling Design Matters

Early in my composites career, I owned a small shop focused exclusively on manufacturing whitewater racing kayaks and canoes, which was really just an excuse to support my own personal racing habit and postpone adulthood. However, it paid some bills and taught me many valuable lessons about vacuum bagging, resin/fiber ratios, delamination, infusion and the importance of good tooling design.

A poorly designed tool transfers a cost and quality burden into every part associated, even if intended for single usage. For example, according to legend, at the 1971 World Whitewater Canoe & Kayak Championships, the Polish team had designed a new type of C-2 (2-man decked canoe) called a Hartung. The night before the race, two Austrians swam across the river under the cover of darkness and “borrowed” two Hartung C-2s from the Poles’ camp. They took them to an abandoned shack and proceeded to fabricate a hull mold from one and a deck mold from the other. The borrowed boats were returned before dawn without the Poles knowing.

A few days later, the Austrians took their new pirated Hartung out for a spin and pronounced it a terrible performer, but assumed they just needed time to get used to the radical new design. They then traveled to a race in England where the telltale design caught the Polish team’s attention so they all gathered around for a look. After a few moments, they erupted in laughter. The Austrians had failed to mark their molds and had been paddling the boat backwards. Tooling design matters!

At my company, Janicki Industries, those questions and other key factors are part of our holistic approach to tooling design. The following list, though not exhaustive, includes typical issues that we take into consideration. This tooling design approach can be used to fabricate everything from shower stalls to wind blades and aerospace parts.

Usage Temperature of Lay-up Tooling

This drives potential coefficient thermal expansion (CTE) mismatches between tool coatings, resin matrix, fiber reinforcement and substructure. Even relatively small differences of 1 – 2 inch/inch/°F over a large tool can cause significant stress resulting in warpage or cracking. A good rule of thumb is to match the CTE of your part materials with the CTE of your tooling for any application above 180 F.

Surface Profile Tolerance

Composite tooling can either be cast or machined. Metal tooling is almost always machined. Due to factors such as expansion, exothermic, shrinkage and a phenomena known as spring-in, cast tooling will not reflect your actual design, with typical variances ranging from +/-0.060 inches to +/-0.125 inches. A common practice at Janicki is to perform computer-aided design (CAD) compensation of surfaces to mitigate these effects. However, machined tooling consistently achieves surface profile tolerances within +/-0.010 inches. Machining also allows for very fine surface features to be included in the tool surface that would be difficult to cast, such as scribes or ply steps.

Tooling Cycle Time

In a higher volume or higher temperature environment, tooling often needs to be cycled quickly and frequently benefits from incorporating heating and/or cooling into the design. A good example is automotive high-pressure resin transfer molding (HP-RTM), which commonly features heated steel tooling in a dedicated press. Another example is wind blade tooling, which is too large to easily move to an oven, so air, electrical or water heating systems are integrated into the composite face sheet. Optimizing tool cycle time also can pay benefits by requiring less total tool count, which reduces facility needs and valuable floor space.
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Getting Materials into the Tool

Tooling bushings (TBs) that allow laser trackers to “clock-in” allow for surface profile verification, ply projection and automated tape laying/automated tape placement indexing and are frequently required by aerospace customers. Marine and wind customers benefit from surface scribes to assist with both edge of laminate (EOL) and edge of part (EOP). Vacuum and/or resin feed ports also can be integrated, thus eliminating potential vacuum bag failures and reducing labor.

Large tools require careful consideration when applying materials. Marine molds are commonly put on pivoting spindles. Another approach is illustrated with a NASA pressure bulkhead tool Janicki fabricated with a suspended walkway that rotates 360 degrees. The bulkhead part was fabricated from out-of-autoclave prepreg that could not be walked on prior to cure or critical air pathways would have prematurely collapsed.

Tooling Life Expectations

A critical issue in tooling design is balancing cost, quality and schedule within the expectations of tooling life. One needs a completely different approach for a single usage 350 F tool than for fabricating 200 parts at 350 F. I frequently see prototype tooling being stretched beyond its design life, which sometimes results in catastrophic failure!

Other factors that drive lay-up tool design are the release systems utilized by customers as well as indoor or outdoor storage. I have seen military tools stored in the desert that are sand etched and boat molds that are stored outside in Maine at -20 F. We recently shipped a tool to South Africa that sat on the deck of a transatlantic voyage. The steel substructure was not adequately painted and became badly corroded.

Tooling Cost

The phrase “there is a right tool for every job” certainly applies, and at Janicki we are stubbornly material agnostic with solutions ranging from $100 to more than $3,000 per square foot. Lower cost solutions exist across all markets, with performance and quality reductions.

Ancillary assembly tooling design is often overlooked, but can play a key role in such activities as trimming part edges, drilling accurate holes and cutting hatches. These do not need to be over-engineered or expensive and often can be fabricated from fiberglass, steel or aluminum. Vacuum clamping of parts is effective, cheap and easy to incorporate.

Spend some time studying your tooling design needs upfront, and hopefully you will avoid putting parts together backwards!

The guest columnist for this issue’s “Best Practices” column is Andy Bridge, vice president of industrial sales for Janicki Industries in Sedro-Wooley, Wash. Email comments to andy.bridge@janicki.com.
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In June 2010, the U.S. Army took a chance by investing in a hybrid blimp/plane/helicopter for its Long Endurance Multi-intelligence Vehicle (LEMV) project. Known as the HAV304, the aircraft was built by Bedford, U.K.-based Hybrid Air Vehicles (HAV) with Northrop Grumman as the prime contractor. Once successfully operational, the Army hoped the aircraft would provide intelligence, surveillance and reconnaissance support for ground troops.

Unfortunately, the HAV304 never reached that point. In 2012, just 25 months after the start of its contract, the aircraft had its first test flight and only flew for 90 minutes. It was deemed unsuccessful for the Army’s needs, so the following year the Army cancelled the LEMV project and the aircraft was bought back by the U.K.

Since then, HAV has won £6 million in grants from the U.K. and the European Union and raised £2.4 million from public crowdfunding to give the hybrid aircraft a second life. HAV officially began its “Return-to-Flight” program in May and gave the HAV304 a new name – the Airlander 10. (The “10” refers to the aircraft’s ability to carry ten tons.) Unlike its previous iteration, this one will be used for more than just military purposes. It also will have commercial applications, such as tourism, cargo transportation, border security and infrastructure surveillance.

Airlander 10 Gets Second Wind

Hybrid Air Vehicles used advanced composite materials to make the Airlander 10, a hybrid blimp/plane/helicopter that is the largest aircraft in the world.

According to Hybrid Air Vehicles, the Airlander 10 will be the largest aircraft ever built. Here's a look at some other quick facts about the aircraft.

**Airlander at a Glance**

- **Length:** 302 feet
- **Weight:** 44,100 pounds
- **Payload Capacity:** Up to 22,050 pounds
- **Altitude:** Up to 20,000 feet
- **Endurance:** 5 days manned
- **Cruising Speed:** 80 knots

**Source:** Hybrid Air Vehicles technical data

The Airlander will incorporate lighter-than-air technology to create what the company calls “a new breed of hyper-efficient aircraft.” The aircraft will get 60 percent of its lift from internal helium gas and 40 percent from its aerodynamic form. A critical component of the success of the aircraft is the boost it gets from advanced composite materials.

“The Airlander hull is made of a flexible laminate utilizing Vectran® as the structural fiber,” says Ashley Appleton, head of rigid structures at HAV. “The laminate contains specific features to protect the material from the environment and to retain helium.”

The skin of Airlander 10’s hull is a combination of five tons of multilayered Vectran weave, Tedlar® and Mylar™ surrounding a helium bubble. This provides strength and endurance that past hybrid aircraft prototypes lacked. According to vectranfiber.com, Vectran, which consists of a high-performance multifilament yarn spun from liquid crystal polymer, is five times stronger than steel and 10 times stronger than aluminum. Tedlar is a polyvinyl fluoride film that provides an outer coat and protects the hull from wearing away. Mylar, a form of polyester resin used to make heat-resistant plastic films, creates a gas barrier to minimize helium loss.

The hull is not the only structure on the revitalized aircraft to rely on composites. The engine frames also were made from an undisclosed carbon fiber prepreg. Underneath the Airlander 10 is a 149-foot-long structure made with CFRP and GFRP materials supplied by Cytec.
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The skin of Airlander 10’s hull is a combination of five tons of multilayered Vectran®, Tedlar® and Mylar® surrounding a helium bubble to provide strength and endurance.

Industries. The structure contains the flight deck, services area, payload bay and a forward fuel tank.

One of the key differences between the HAV304 and Airlander 10 is the modification to the payload module. According to Nick Allman, director of the Airlander 10 program, the payload module has been converted from a pure military surveillance aircraft to a flexible, multi-use trials and demonstrations aircraft.

HAV has said in other interviews that the Airlander 10’s composite construction allows it to withstand multiple lightning strikes. In addition to added strength, composites provide the Airlander 10 the lightness today’s aerospace market demands. HAV estimates that using advanced composites instead of traditional metals for the rigid structures helped save between 50 and 60 percent total weight on the aircraft. “Composite usage will continue on the Airlander 10 wherever possible,” says Appleton.

The Airlander 10 has already captured the attention of many private investors, most notably Iron Maiden lead singer Bruce Dickinson, who now doubles as a part-time pilot. Early last year, Dickinson announced he wants to fly the Airlander 10 around the world twice. HAV says the plane is scheduled for its first test flight in early 2016.

HAV’s website notes the Airlander 10 will eventually have a “big brother,” the Airlander 50, designed for remote access and logistics in markets such as mining, oil and gas and humanitarian relief. Allman says that composite knowledge and expertise gained on the Airlander 10 will be utilized for the Airlander 50.

Evan Milberg is communications coordinator for ACMA. Email comments to emilberg@acmanet.org.

For more stories like this, visit CompositesManufacturingMagazine.com and check out the Aerospace articles under the “Market Segments” tab.
Since 1820, Brookfield, Vt., has had a unique claim to fame. Its Sunset Lake features the only floating bridge east of the Mississippi River. The Brookfield Floating Bridge originally hovered at the waterline as a creative system of timber over floating barrels. However, the roadside attraction has needed repeated updates to keep it afloat. In 1978, the bridge was reconstructed for the seventh time using a series of 380 plastic, foam-filled floats that supported a single traffic lane and pedestrian walkways.

In time, those floats also began to fail, and the bridge sank lower and lower, leaving only the most determined drivers to cross the watery path. In 2008, the bridge was shut down entirely to vehicular traffic. But the Vermont Agency of Transportation was not ready to give up on the historic tourist attraction. In its plans to bring the bridge back to life, the agency had a very clear idea of what the updated structure would need to accomplish—and it determined that composite rafts would be the best option to meet its strict requirements. In the early planning stages, the engineer of record, T.Y. Lin International in Falmouth, Maine, considered concrete as a familiar and relatively inexpensive solution for keeping the historic bridge afloat, but a cost-benefit analysis revealed GFRP as a clear winner. Among other reasons, concrete rafts would require significant dredging to the site to accommodate their expected 10-foot depth and the necessary eight feet of draft. GFRP rafts, on the other hand, would need only a 3-foot depth with one foot of draft and, unlike the concrete rafts, would feature flotation foam within to keep them afloat even in the event of a leak. In addition, GFRP allowed for offsite construction, which offered big benefits.

“Concrete would be pretty massive and would have to be built onsite with significant impact to the surrounding environment. It would also be a bit more time consuming,” says Josh Olund, P.E., bridge engineer for T.Y. Lin. GFRP would allow for the use of smaller cranes at the cramped installation site and would be comparatively inexpensive to transport. Durability also was a factor. The engineers predicted a 100-year design life for the GFRP rafts, with only biennial inspections required.

While the material advantages were fairly cut, one significant challenge to the plan stood out. “From an FRP...
At the time of construction, the 52-foot-long molds used to create the ten pontoons for the Brookfield Floating Bridge marked the largest single vacuum infused part that fabricator Kenway Corp. had produced.

standpoint we really didn’t have much for a design code to go by,” Olund says. There are no composite-specific design guidelines for bridges and little information on general structural applications for composites, the engineer found. “It seemed there were a lot of manufacturer-written manuals about how they go about design and how they would suggest implementing those designs. Still, to take that from a global perspective and to actually turn that into a project was difficult,” Olund says.

T.Y. Lin applied the “LRFD Bridge Design Specifications” from the American Association of State Highway and Transportation Officials to develop load requirements for the updated bridge. It also relied on the manufacturing expertise of partner Kenway Corp., a custom fiberglass manufacturer based in Augusta, Maine. For its part, Kenway used the “Pre-Standard for LRFD of Pultruded FRP Structures,” developed by ACMA and the American Society of Civil Engineers, to calculate analysis requirements and resistance factors.

The research was crucial because,
Despite the lack of available structural guidelines, the client had very strict quality and dimensional tolerances that the bridge needed to meet. “It was a 255-foot floating span, and they wanted it to come together within +/- ½-inch on that entire length,” says Jacob Marquis, P.E., the senior project engineer for Kenway who consulted on the project. Given that firm length tolerance, the manufacturer faced challenges in adjusting materials to account for the rafts’ expected expansion and contraction through different temperatures. “We had to adjust our parts and our molds in order to achieve the specified length after adjusting to a reference temperature of 40 degrees,” Marquis explains.

Once general contractor Miller Construction officially brought Kenway on board as its design-build partner, the manufacturer faced a new challenge. The fabricator designed and built the fiberglass-over-wood molds to measure 52 x 12 feet. “At that time it was the largest single infused part that we had to make,” Marquis says.

The end result was a series of five foam-filled GFRP rafts spliced together. Each raft comprises two pontoons bonded together, and each pontoon has eight watertight, foam-filled compartments. Altogether the rafts feature 31,000 pounds of vinyl ester resin, reinforced by 78,000 pounds of mat, biaxial and double bias fiberglass. Fillers include a UV inhibitor and a “Federal Gray” pigment that helps the rafts subtly mimic the timber that would be placed on top. In addition, steel post-tensioning rods were passed through each pair of pontoons to help clamp the pontoons together during the final raft assembly, as well as to provide redundancy to the bonded joint.

Production was both big and fast. Each pontoon had to meet an aggressive one-week start-to-finish production schedule. Overall, it was a very forward-thinking approach to keeping a historic structure intact. Whether walking, fishing, swimming or driving, visitors using the bridge today may be more focused on the structure’s connection to history. But without the pontoons, the bridge might not have had a future.

“[The rafts] are decked over with a significant amount of timber in order to make the bridge look like what was there before, from the historic preservation perspective. Very little of the composite raft is visible; from the side you can see about a foot of the pontoon,” Marquis says. “But the pontoons themselves make up not only the flotation for the bridge – they are essentially the structural backbone of the bridge.”

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For more stories like this, visit CompositesManufacturingMagazine.com and check out the Infrastructure articles under the “Market Segments” tab.
Making Drops to Drink

The sailor in the 18th century poem “Rime of the Ancient Mariner” got it right when he said, “Water, water, everywhere, nor any drop to drink.” When surrounded by seawater, you’re fresh out of luck if you’re thirsty. However, that situation may be changing, thanks to desalination projects that turn salt water into fresh water.

A case in point comes from a plant soon to be completed in Carlsbad, Calif., located at the northern end of San Diego County. Owned and developed by Poseidon Water, the plant will provide clean water to approximately 300,000 people, and FRP composite piping plays a key role because of its material properties. “For large diameter, above ground, low-pressure piping, IDE finds composite piping to be the most suitable,” says Ziv Shor, project manager for IDE Technologies.

Based in Kadima, Israel, IDE Technologies specializes in the development, engineering, construction and operation of enhanced desalination and industrial water treatment plants. The company built the largest desalination plant in China and also built and operates the largest desalination plant in the world, which is located in Israel. IDE is the process designer and equipment supplier for the Carlsbad Desalination Plant and will operate it.

For California, the development of additional water supplies is critical, which is why the Carlsbad Desalination Plant is important. The state is facing one of the most severe droughts on record, resulting in a government edict for a 25 percent reduction in water usage state wide. Being able to economically transform previously undrinkable seawater into useful drinking water could be part of the long-term solution to the crisis.

Shor says the Carlsbad facility is a game changer. It’s the largest desalination plant in the Americas and is the first major California infrastructure project with a net zero carbon footprint. The plant’s design is based upon IDE’s reverse osmosis technology. In reverse osmosis, unwanted contaminants, like salt, are removed by forcing water through a semipermeable membrane. On one side of the membrane you get drinking water. On the other, you
Water produced at the Carlsbad Desalination Plant will be conveyed to the San Diego County Water Authority’s system via a 10-mile pipeline and provide high-quality drinking water for more than 300,000 people in the county.

get an effluent with a higher concentration of brine, making it corrosive. In the Carlsbad plant, IDE used what it calls an innovative pre-treatment phase to improve efficiency and reduce energy consumption.

Up to 108 million gallons a day of salt water will go in for treatment, with an average of 50 million gallons of high-quality drinking water coming out. That water travels through 10 miles of pipeline, so it’s an important component for the success of the entire project. For some of the piping, GFRP composites were selected over alternatives like high-density polyethylene (HDPE) due to the former’s greater strength and smaller longitudinal expansion, Shor says.

Ershigs of Bellingham, Wash., designed and manufactured the above ground GFRP piping. “FRP is widely used and proven in desalination globally,” says Steve Guay, general manager of the Ershigs facility that built the piping. “The value proposition is internal and external corrosion resistance in a sea water and seaside environment.”

The Carlsbad piping ranges from four to 72 inches in internal diameter. Ershigs produced 1.3 miles of piping, with a total weight of half a million pounds. It took the company from late 2013 to early 2015 to design, manufacture and deliver the piping to the project. Most of that time was spent manufacturing via filament winding.

Ershigs used Reichhold’s DIION® 9102 series of bisphenol-epoxy vinyl ester resins for a corrosion barrier, with Ashland’s HETRON® 922 epoxy vinyl ester resin in the structural layers. For structural reinforcement, the company used Owens Corning C-glass veil, chopped strand E-glass mat and E-glass woven rovings.

Ershigs faced some challenges producing and delivering the piping. The project’s construction schedule, for instance, was demanding and required some ingenuity to meet. Complying with the NSF-61 drinking water sanitation standard meant that the assembled fiberglass spools had to undergo a heated post cure. That took time and could have impacted the project schedule.

To deal with that, Ershigs’ metal division fabricated two custom roll-in racking systems, says Guay, “which allowed us to stack multiple spools into our post cure oven, thereby maximizing usage of the available cubic feet of the oven and minimizing the FRP spool handling and ultimately any potential delivery schedule impacts from the post cure activity.”

In meeting the schedule, it helped that Ershigs has its own specialty construction division, says Julie Delaney, project manager. The experience gained in supporting that division made it easier to address the Carlsbad project priorities, sequencing and coordination. In the end, 91 truckloads of piping rolled from Ershigs’ manufacturing plant in Bellingham to the jobsite in Carlsbad.

“Although this important project was high profile, completion of Ershigs’ scope was fairly straightforward,” says Delaney.

While composites are used extensively in the Carlsbad project, Shor says they could play an even bigger role in future desalination plants. For instance, stainless steel alloys containing chrome and molybdenum for corrosion resistance are currently used for the high-pressure piping through which the corrosive effluent travels. The pressure in the piping reaches roughly 1200 psi, meaning that a composite pipe would currently have to be unacceptably thick to be used. However, Shor notes that ongoing research and development efforts could change the cost calculations that today favor stainless steel over composites.

“We believe that such [composites] technology will eventually be a common standard for high-pressure corrosive effluent in the coming years,” Shor says. Such advances could further improve the cost effectiveness of desalination. With the success of such projects, landlubbers and mariners, ancient or otherwise, will finally have something to drink.

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For more stories like this, visit CompositesManufacturingMagazine.com and check out the Infrastructure articles under the “Market Segments” tab.
Industrial designers and engineers value composite materials primarily for structural properties such as light weight, stiffness and high strength. With rapid advances in the field of multifunctional composites, however, they may soon be looking at composites to provide many other properties as well.

Multifunctional materials and systems have more than one primary function occurring simultaneously or sequentially in time, according to James Thomas, section head of the Naval Research Laboratory’s (NRL) Multifunctional Materials Branch. They enhance system level performance by eliminating the redundancy between subsystem materials and functions. One function is usually structural – maintaining a shape or carrying a load – while the others could be anything from self-healing, thermal conduction or energy storage to damping, sensing or electromagnetic conductivity.

The distinction between multifunctional materials and systems has become blurred, especially as systems become smaller and smaller. Thomas says one difference is that multifunctional materials preserve the various functionalities even if the material is divided into parts. A multifunctional system, on the other hand, might lose some functionality if certain sections of the material are removed.

“The distinction is, in some sense, the size scale,” says Scott White, a professor in the Department of Aerospace Engineering at the University of Illinois at Urbana-Champaign (UIUC) and at the Beckman Institute for Advanced Science and Technology. He compared multifunctional systems to a bridge built with a network of sensors and electromagnetic dampers that could be signaled to clench when undesirable vibrations threaten the bridge structure. With a multifunctional material, “rather than a bridge that has a sensor and actuator attached to it, the material you build the bridge from itself is monitoring vibrations and damping them automatically.”

Thomas’ group at the NRL began working with multifunctional composite systems in 1999 under contracts with the Defense Advanced Research Projects Agency (DARPA). Researchers embedded custom-shaped lithium ion cell batteries into the composite wing structure of unmanned air vehicles (UAVs), removing some wing structural weight. They also embedded battery cells into composite structural beams for an unmanned
underwater vehicle application to free up volume in the hull and provide space for additional energy storage or payload.

Thomas and his colleagues are currently studying poro-vascular composites. These consist of a thin laminate skin material with internal, fluid-filled vascular channels that connect to pores on the surface. The researchers control the liquid, moving it in and out of the pores to produce changes in the surface from flat to rough with spherical bumps or dimples like a golf ball. Changing surface roughness could provide a new method of aerodynamic control of UAVs.

Self-healing Capabilities
Researchers at both UIUC and the University of Massachusetts Lowell have been working with multifunctional microvascular materials that mimic the human body’s healing abilities. When people cut themselves, the blood clots and cells are autonomously recruited to the site, where they proliferate and remodel and eventually heal the injury. “So we build structural materials that sense the damage and then do something that leads to structural recovery and healing from that damage,” says White.

Self-healing systems would be especially valuable in space applications, where missions now rely on system redundancy to guard against structural failures. That adds both weight and cost. With a self-healing structure, the likelihood of a successful mission increases without the added weight.

UMass Lowell started its research into self-healing composites by experimenting with microcapsule-based systems that rupture and release their contents when a cracked plane is propagating.

“This is usually a fluid that can be polymerized, and once it polymerizes it bonds the interfaces of the cracked face together,” says Christopher Hansen, assistant professor in the Department of Mechanical Engineering. But microcapsules contain a finite amount of fluid, which limits the damage repair.

“With a microvascular system, you can pump fluid to wherever the damage is. You can heal multiple times and heal much larger scale damage,” he says. So researchers at the school have created microvascular channels within a composite by embedding a plastic material into a thermoset. Once the thermoset process is complete, they heat the composite again and the plastic decomposes into a gaseous form, leaving open channels behind.

White, who is heading similar research at UIUC, sees these channels opening up a whole new range of possibilities. “With microvascular systems, our original motivation was to overcome the limitations of capsule-based healing systems, but once we had a circulatory network all of a sudden we could do almost anything we wanted,” he says. “Not only can you heal materials by circulating a healing agent, but you can cool these materials by circulating a coolant or you can put a dye in the fluid stream and detect where it leaks out to track damage. It’s the ultimate multifunctional material because the functionality is dictated by the fluid that you put into it.”

Adding Conductivity
While research goes on at the university level, private companies have been developing their own methods of making composites multifunctional. Conductive Composites has focused on adding conductivity properties to composites while retaining their strength, weight and corrosion advantages. The company’s solution is a proprietary vapor deposition process that places an ultrathin nickel coating on every strand in a composite bundle made from carbon, aramid or other fibers. The thickness of the coating varies according to the properties that a particular application requires.

The process does increase the strength, stiffness, brittleness and density of the composite slightly, but in return the customer gets a composite that can block radio waves or carry electricity, according to Nathan Hansen, company president. The company is working with both industrial and government partners to develop new applications for its function-adding process.

Conductive Composites currently makes lightweight composite faraday cases, which are injection molded cases that provide the same electromagnetic interference (EMI) shielding as heavier metal cases (often called faraday cages). It is exploring the use of nickel-coated composites to make more sensitive fishing rods and to produce lightweight composite antennas that perform as effectively as aluminum antennas.
A key application of Tecnofire® intumescent materials is fire protection for composite structures. The materials are made from exfoliating graphite, high temperature-resistant mineral fiber, an organic binder and, in some cases, additional particulates, fibers or active ingredients such as alumina trihydrate.

While there are additional costs associated with the vapor coating system, Hansen says the focus should be on the entire value proposition. “By adding conductivity capabilities built right into a system it makes a fundamental change. The composite does something that it wasn’t doing at all before.” That opens up many new opportunities for composite materials.

**Bringing in More Functions**

Technical Fibre Products (TFP) is a specialty, wet-laid nonwoven manufacturer that produces veils and mats that become a layer within a composite material. That layer can add a single new function to a composites – fire protection, conductivity or EMI shielding, for example – or some combination of functions.

Take construction, for instance. “Composites are being used more and more for design freedom for shapes but also for structural purposes,” says John Haaland, TFP president. “But one of the hurdles for resin-rich composite material is that it has to meet fire resistance.” TFP’s Tecnofire® product can solve that problem. Incorporated near a composite’s surface, Tecnofire is an intumescent material that expands to form an insulating char when it is activated at temperatures above 190 C. It enhances the composite material so it becomes part of a building’s fire protection system. TFP is now adding other materials to make the composite electrically conductive as well as intumescent.

“If we can adjust the raw materials so that we can use a small current to activate the intumescence, we can then activate the fire protection barriers in advance of a fire,” says Mandy Clement, TFP technology manager. Such systems could contain a fire within one area and seal off other sections to minimize fire and smoke damage.

TFP also produces very light thermoplastic materials and a carbon veil that weighs two grams per square meter. The lightweight thermoplastic materials can be interleaved into a carbon composite to improve fracture toughness. Functions such as conductivity can be added as well, depending on the composition of the thermoplastics.

“We can change the fiber types to exactly what the customers are looking for; we can blend different materials, we can add in particulates. We are really tailoring the product to specific customer requirements,” Clement adds. “One of our key skills is trying to develop the material in such a way that it isn’t going to be detrimental to other properties in the composite.”

**Between the Plies**

The carbon nanotubes (CNTs) used by startup company N12 Technologies Inc. to strengthen laminated composite structures also can add conductivity. The company’s NanoStitch™ product, added during composite layup, reduces delamination by inserting trillions of vertically-aligned CNTs within the resin interface between plies. N12 says the CNTs increase interlaminar fracture toughness by 30 percent.

But NanoStitch provides other benefits, too. “The resin-rich interface between plies is a poor conductor in comparison to carbon fiber. High-conductivity CNTs connecting adjacent plies conduct heat and electricity through what is normally an insulating layer,” says Christopher Gouldstone, lead applications engineer. The N12 Surface Layer System™ can improve in-plane thermal and electrical conductivity. “We take our vertically-aligned nanotubes and we orient them in the plane, so we essentially knock them over. That gives you a conductive film that can be put on the surface of the composite to do all sorts of applications like heating or sensing,” Gouldstone says.

“In multifunctionality you often hear about heating and sensing applications, but oftentimes it’s improving conductivity that allows the structure to perform other roles,” he continues. Composites used in spacecraft, for example, offer the advantage of being lightweight but have not been as effective as metals when it comes to transferring heat. A multifunctional composite with conductive properties could provide both light weight and thermal transfer properties.

**Manufacturing Multifunctionals**

Almost any composite material can be made multifunctional, although it’s harder to do with certain materials than with others. For the most part, the companies now producing multifunctional materials say that manufacturers will have to make few changes to their current production processes to incorporate new products.

But there are some limitations. When NRL embedded batteries into aerospace composites, for example, it couldn’t use autoclave processing because the required high temperatures degraded the battery performance.

“On the design side, multifunctional composites typically involve significant tradeoffs, so you have to do an optimization to look at what those tradeoffs are,” says Hansen of UMass Lowell. “Typically people who want the best structural function are loath to give up a little bit of that structural performance to enhance the overall system performance.” System integrators may better understand the pros and cons of such tradeoffs.

Hansen says much of the design work with multifunctional composites has been done at the research level. But translating the technology to industry lags, so researchers are making an increased effort to find production methods that cater to manufacturers’ needs. “Is there a way that we can integrate
[functions] into the fabric structure so that it’s just another thread that is woven in? Is there a way that we can apply it to the prepreg so that the manufacturing process is just as simple as it always was? We’re trying to be creative in reducing complexity,” says Hansen.

Companies considering the use of multifunctional composites have to look at the total system cost. While it may be more expensive upfront to add conductivity or thermal sensing to the composite, they might save money later on in the process by eliminating the need for a second, separate system.

Researchers and businesses working with multifunctional composites today see an increasing need for these materials in the future as the composites industry enters new markets.

“You could probably count on one or two hands the number of combinations of functions that have been demonstrated so far,” says White. “But those are going to simply explode and rapidly proliferate over the next five to 10 years, and you will have hundreds of examples of multifunctional materials.” He envisions, for example, multifunctional systems that can regenerate large sections of structures, much as the body constantly replaces bones.

“We don’t need to build a bridge that lasts for 100 years. We need to build a bridge that lasts for seven years, but continues to replace itself every seven years,” says White. “That’s the concept that we need to move toward.”

Mary Lou Jay is a freelance writer based in Timonium, Md. Email comments to mljay@comcast.net.

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**Don Lipp**

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Composite Collaborators

Teaming up with designers, engineers, architects and other experts can lead to novel applications and help advance the industry.

By Susan Keen Flynn
Innovation requires collaboration. Consider the Curbside Pickup Pod: The deceptively simple GFRP kiosk, which resembles a bus stop shelter, is the byproduct of new way of shopping introduced by a startup company called Curbside (shopcurbside.com). The company’s founders created an app, which consumers use to order items from stores including big-box leaders Target and Best Buy. Within a half hour or so, those items are waiting for pick up at a kiosk outside the store or mall. Consumers pull up to the Pickup Pod and collect their merchandise from an attendant – no time wasted searching for a parking space or standing in line in a store. And they receive items faster than if they ordered online and waited a day or more for delivery.

The Pickup Pod is the physical presence at the back-end of Curbside’s high-tech business. But it took just as much brain power to pull together as the digital juice that fuels the company. The team that developed the kiosk included engineers from Curbside, renowned architect Greg Lynn, composite fabricators Kreysler & Associates and civil engineers from Martin/Martin Inc.

Teamwork was critical to the creation of the kiosk – the first of which was installed at Glendale Galleria in Los Angeles in August – as it is for most composite applications. “Nobody can be an expert at everything,” says Bill Kreysler, president of Kreysler & Associates Inc., American Canyon, Calif. “If you bring together a group of people who have expertise in their various fields and everyone contributes, you’re going to be better off than if one person tries to do everything.”

What Drives Partnerships

Selling composites necessitates more than a “quote-and-a-handshake” approach. It takes a village to devise composite solutions, from designers and architects to engineers and OEMs. Companies partner with customers as well as outside consulting firms to ensure that visionary ideas ultimately translate into functional composite applications.

One of the primary reasons collaboration is so important is because most applications are custom. Mar-Bal Inc., a compounder and molder of thermoset composite products based in Chagrin Falls, Ohio, provides components for numerous consumer appliance brands, including GE, KitchenAid, Electrolux, Whirlpool and Maytag. “Each component has very unique and specific attributes,” says Marc Imbrogno, director of materials engineering for Mar-Bal. “In order to achieve those attributes – and a satisfied customer – you want to be engaged as far upstream in the design chain as possible.”

The company partners with customers to create components ranging from dishwasher handles to oven vent trim that are durable and attractive. “We try to get involved as early as possible with OEMs and work with their designers and marketing team to give them the look they want,” says Dave Phillips, lead engineer for custom products at Mar-Bal.

Phillips teamed with industrial designers and engineers at Whirlpool a couple years ago on a new control panel for ovens. The appliance manufacturer provided a part model and 2D design for Phillips to review. He did a complete design for manufacturing (DFM) analysis, considering such issues as whether the part could be molded, if it required any special features and where it should attach to the oven. Phillips offered a handful of design suggestions, including a modification that would allow the same control panel to be used for both gas and electric oven models, which would save Whirlpool time and money in tooling and changeovers.

Collaborating also ensures that companies capitalize on the particular areas of expertise that each party brings to the table. This is especially important for Kreysler & Associates, which does a lot of projects in the construction industry. “No composite engineers are experts in building codes and in the complexity of integrating a variety of systems into a single building,” says Kreysler. “Likewise, there’s no civil or structural engineers in the construction industry who are experts in optimizing composite materials for a particular application.”

Success depends upon a meeting of the minds. “We live in two different worlds in terms of composites and construction,” says Brent Hanlon, a professional engineer with Martin/Martin who has worked with Kreysler & Associates on several projects. “Ultimately, it takes a team approach to build something.”

Hanlon consulted with Kreysler on the Curbside Pickup Pod. “They had already done most of the problem solving, then we provided the necessary backup calculations and told them what changes would be required to get approval from the local building department,” says Hanlon. “When dealing with alternative materials, building departments and engineers get a little squeamish. That’s where we can be valuable, step up to bat and talk the same language as the code official.”

One of the building department’s concerns was how the kiosk would anchor to the concrete. Hanlon helped redesign the

◆Serge Labesque, top left, and Julie Steier of Kreysler & Associates share thoughts on an architecture project with a cladding contractor.
Brad Doudican, right, president of Advantic LLC, has made several trips to Australia to collaborate with his customer, Stephen Foley, senior civil and structural engineering advisor with Newmont Mining Company.

anchor so it would meet approval. “If you’re bolting a kiosk down to a sidewalk, maybe the sidewalk is strong enough to do the job and maybe it isn’t,” says Kreysler. “I defy you to find me a composite engineer who would know the answer to that question.” Partnering with Hanlon, as well as another civil engineer who performs finite element analysis, helps ensure that anything Kreysler builds from composites interfaces with the rest of the building or foundation.

Composites also are affected by the environment, which presents another reason for aligning with other experts. Last year, Advantic LLC in Dayton, Ohio, worked in tandem with Newmont Mining Company and Kalgoorlie Consolidated Gold Mines (KCGM) to develop a composite repair and structural strengthening system for coarse ore stockpile covers at the KCGM Fimiston Operations in Australia. One of the main challenges was constructing a solution for use in another country. “I’ve never built something in Australia,” says Brad Doudican, president of Advantic. “I don’t know the cultural norms of construction and what materials and tools I’ll have available. It’s in the middle of the outback. It’s not like you can go to Home Depot.”

A structural advisor from Newmont and a structural engineer from KCGM worked alongside Doudican, also an engineer, for several months to create what he now calls the Advantic Structural Composite (ASC) Jacket. It’s comprised of a thin exterior stainless steel skin and interior structural cast polymer core machined to the engineered thickness requirement and surface profile of the structural member to which it will be bonded. “We had to consider the best materials to overcome the challenges of doing a controlled surface profile in the middle of the desert on a windy day,” says Doudican. “It was not a trivial activity to get a feasible solution.”

**How Companies Collaborate**

Doudican first met representatives of Newmont Mining at Structures Congress 2014, a conference and trade show for structural engineers hosted by the American Society of Civil Engineers. The $7.2 billion mining company was seeking solutions for a remediation project in Australia. Advantic was demonstrating the unique properties of composite materials on the show floor. The relationship between the two companies began with a chance conversation in a trade show booth.

“It was your classic ‘back-of-a-napkin’ story: Draw a few sketches, show us your problem and then let’s talk about it,” recalls Doudican. “But that’s the critical piece. Customers have the best information as to what their problem is — or what they perceive it to be — and it’s our job to figure out how to solve it.”

Immediately following the conference, Doudican began weekly conference calls with Newmont Mining and its subsidiary KCGM to devise a solution to repair and strengthen dilapidated coarse ore stockpile covers at the processing plant for the Fimiston open pit, widely known as the “Super Pit” because it’s the largest open pit gold mine in Australia. The structural covers, which are nearly 260 feet in diameter and 104 feet tall at their highest point, support a large conveyor belt. Doudican demonstrated the feasibility of its solution and provided a roadmap for the project.

In May 2014, Advantic landed a contract for preliminary design, which included a review of the design by a third-party structural engineering firm. A month later, Newmont and KCGM selected Advantic’s composite solution from more than a dozen other proposals. In July, Doudican traveled to Australia for an on-site constructability review with KCGM’s management team, engineers and contractors. The ASC Jackets were fabricated in Advantic’s Ohio facility throughout the fall, then delivered and installed at the mine between December 2014 and February 2015.

The complex project couldn’t have come to fruition without teamwork. “The working relationship with Advantic was very professional and collaborative,” says Stephen Foley, senior civil and structural engineering advisor with Newmont. “The concept we were advancing had never been undertaken, to our knowledge, so we were reservedly optimistic about the potential outcomes. As such, we required close oversight as the concept progressed.” Foley and others provided input on the engineering drawings, structural models, Australian standards and codes and more.

“Without their perspective, could we have arrived at a solution? Sure,” says Doudican. “But would we have had as much success without dual integration of activity? No way!” The relationship fostered on this project has led to other business with Newmont and KCGM. “Advantic’s ability to think outside the box when it comes to problem solving is a key motivator in our continued business,” says Foley. “They demonstrated commitment to understanding the true nature of problems.”

There’s no set formula for partnering with engineers, designers, architects and other stakeholders in composite applications. It varies from project to project, says Kreysler. His firm typically comes up with a fundamental design, then calls on engineering associate Kurt Jordan to perform finite element analysis on complicated shapes to verify that the sizes and connections are correct. Then an engineering firm such as Martin/Martin comes in to define the load and thermal conditions and stamp the relevant documentation.

Some composites professionals may be uneasy working so closely with others because they’re reluctant to share proprietary information or afraid someone will steal their business. Get over it, says Kreysler. “You don’t see the brain surgeon looking over the shoulder of the anesthesiologist thinking to himself, ‘Well, next...
time I’ll just do that myself,” he says. “If you’re worried about your secret stuff, then you’re going to suffer the consequences of missed business opportunities.”

Other people may be hesitant to admit knowledge gaps. “You’re paid by customers to have answers, and when you don’t immediately that can be a challenge,” admits Doudican. “We try to spin that and say, ‘You’ve got problems, and we’ve got a toolkit. Together, we’re going to arrive at a solution.’”

Tips for Fostering Teamwork

Working together. That’s the key. Companies that are experienced collaborators offer the following advice for forming relationships with customers and other parties involved in complex projects:

- Meet local architects, engineers, designers and contractors. “Sit down with them, and tell them what you do,” says Kreysler. “Tell them you want to learn what, if anything, you can do for them to get your foot in the door.”

- Get involved early. “The farther upstream we can get in the process and the better we understand where our customers are headed, the more likely we can work in parallel to formulate value-enhacing concepts that they may be able to integrate into their products,” says Imbrogno.

- “Park the data dump,” adds Imbrogno. “Forget telling customers what you can do. Become knowledgeable about your customers’ markets – what’s going on from a product, technology and business standpoint.” Armed with that knowledge, you can formulate ideas that will meet their needs rather than serve your own.

- Seek out likeminded partners. “We like to solve problems with people who want to solve problems, too,” says structural
engineer Hanlon. “It’s exciting as an engineer to push the limits a little bit instead of doing the same old building we’ve done 100 times. If I’m designing a steel structure, I open up my steel manual for a list of instructions that tell me what to do. Working with composites is fun! It appeals to me to throw out the cookbook, use my brain and think up solutions to problems.”

• **Be patient.** “Engineers are not by nature risk-takers,” says Hanlon. “To use an alternate material that is not proven, you might have to jump through some hoops. It’s getting easier as we continue to build successful projects, but for the time being I would caution patience and fortitude.”

• **Teach customers about composites.** “The Newmont and KCGM team had limited exposure with composites in the structural engineering world, mainly in regard to strengthening suspended concrete elements,” says Foley. “Advantic was happy to provide a ‘Composites 101’ class to our team, walking us through the fundamentals of composites, applications, costs, advantages and challenges. They let our team probe, query and interrogate in detail to ensure we were satisfied with the direction of this emerging option.”

• **Look beyond engineers and designers.** “Marketing and procurement departments have goals, too,” says Imbrogno. “Know the metrics by which they are judged and what’s important to your customer contacts, no matter what role they’re in.”

• **Listen to your partners.** “We look for partners who are open to input because we bring a lot to the table,” says Hanlon. “Their paths to building will be much easier if we are involved. But it’s hard to go to bat for someone who doesn’t listen to the advice you’re giving as a consultant.”

Being receptive to collaboration opens up possibilities in the composites market. Your partners can become an extension of your business, creating new business opportunities. In October, engineering firm Martin/Martin hosted an informational meeting about composites for a large architecture firm in San Francisco, encouraging the architects to consider composites for the next arena they design. “It’s a material that architects will love because of its flexibility of form,” says Hanlon. “The cost is sometimes a barrier, but with the right project we see composite façades emerging as the next iconic architectural material.”

Advancing composite materials is largely a matter of the right people coming together. “What a great opportunity to find likeminded people from the buy side of the table to advance the state of the art in composites,” says Doudican. “I get to work with people who want to take structural engineering and advanced materials and innovate in new spaces within the civil market. It’s got huge potential. It just takes the right pairing of people who can collaborate and bring solutions to fruition.”

Together, anything is possible.

Susan Keen Flynn is managing editor of *Composites Manufacturing* magazine. Email comments to sflynn@keenconcepts.net.
The $330 billion global medical device market is a burgeoning industry that is increasingly turning to composites for technological advances. Comprised of millions of different products to help diagnose, treat and ease the effects of disease and injury, the medical device market includes a vast range of products from simple tongue depressors and bed pans to highly complex surgical lasers and MRI machines.

The medical device market is expected to grow 6 percent through 2017, according to DeciBio, a market research and consulting firm specializing in the medical industry. Areas where composite materials will see increasing growth include orthotic and prosthetic devices, 3D printed applications and components for large-scale MRI equipment.

But composites are used for much more than just supplementary devices. Researchers are integrating advanced materials into medical treatments, too. A glance at five applications – from cancer therapies to wheelchairs – shows the extent to which composites have penetrated the healthcare industry.

Cancer-fighting CNTs

Perfection isn't everything – at least when it comes to carbon nanotubes and the fight against cancer. Ongoing research at Yale University demonstrates that small imperfections in the topology of carbon nanotubes may provide an optimal surface for growing cancer-fighting cells.

The researchers are using carbon nanotube (CNT) polymer composites to incubate cytotoxic T-cells – nicknamed “killer cells” because these white blood cells attack and kill infected or cancerous cells. The novel technique is being tested for use in adoptive immunotherapy, an emerging treatment in which cells are removed from a patient, enhanced in the lab and then injected back into the bloodstream to boost the patient’s ability to fight infection or cancer.

As reported in the journal *Nature Nanotechnology* last year, the Yale scientists created the new cancer-fighting composite by attaching antigens and polymer nanoparticles to a bed of CNTs. The polymer nanoparticles contain magnetite and the T-cell growth factor interleukin-2 (IL-2). These carbon fiber nanotube-polymer particles (CNP) were then used to grow T-cells, which were magnetically separated from the CNPs, reintroduced into the study's mice and shown to be effective in delaying melanoma tumor growth. The study authors say that the combination of the CNT high surface area and nanoparticles releasing a T-cell growth factor leads to quicker and greater expansion of T-cells outside the body for cancer immunotherapy.

Composite Remedies

There’s a healthy forecast for high-performance materials in the medical market.

By Melissa O’Leary

The seat, backrest and wheels of the Carbon Black wheelchair are made from CFRP.
Composites Manufacturing

This plate to repair femur fractures is made from PEEK-OPTIMA® Ultra Reinforced composite materials from Invibio Biomaterial Solutions.

“In repressing the body’s immune response, tumors are like a castle with a moat around it,” says Tarek M. Fahmy, associate professor of biomedical engineering and immunobiology at Yale University and the study’s principal investigator. “Our method recruits significantly more cells to the battle and arms them to become super killers.”

T-cells are typically grown on a variety of high surface area platforms that include magnetic and latex beads. However, these methods are too expensive and time consuming to be widely used, according to the researchers. Efficiencies in the new CNT therapy may change that. Fahmy and his colleagues used the CNTs to expand T-cells 200-fold over 14 days, while also using 1,000 times less IL-2 than other methods.

This efficiency is partially due to the unique and imperfect topology of nanotubes. Fahmy stresses that nanotubes provide a high surface area that is rich in surface defects. These structural gaps facilitate the absorption of proteins and nanoparticles, creating a structural environment similar to the body’s own T-cell producing lymph nodes. In other words, a good environment for T-cells to cluster and grow.

The use of inexpensive, easy-to-use magnets to isolate T-cells after they are incubated provides efficiency. Together with the widespread availability of carbon nanotubes and biodegradable polymers, the Yale researchers are optimistic that the new CNT immunotherapy could be the economical “off-the-shelf” therapy for chronic infections and cancers that many have long been waiting for.

Composite Trauma Plates

For decades, bone fracture surgery has relied on metal screws, pins, rods and plates to repair compound fractures or other severe breaks. In March, Invibio Biomaterial Solutions of Lancashire, U.K., introduced an alternative – trauma plates made from PEEK-OPTIMA® Ultra-Reinforced high-performance composite materials.

Invibio says that the plates, which feature a polyetheretherketone (PEEK) polymer reinforced with continuous carbon fiber, have mechanical strength that is similar to metals, but with a reduced stiffness like that of cortical bone. Metal, which is much stiffer than bone, can cause stress shielding and delayed healing, according to the company. PEEK-OPTIMA Ultra-Reinforced plates also have shown 50 times greater resistance to fatigue, making them more durable over time.

Another benefit of composite trauma plates is their radiolucency, which means they appear nearly transparent on X-rays. This allows for a clear view of the fracture site to assess healing and identify infection. In addition, the plates are biologically inert and have low tissue adhesion. This, combined with the lack of cold welding, may make removal of the device in follow-up surgeries less complicated and help preserve the surrounding bone.

Invibio has received endorsements from orthopaedic surgeons, including Dr. David J. Hak from Denver Health, University of Colorado. “Patients who are at risk for slow or delayed healing can benefit from implants composed of PEEK-OPTIMA Ultra-Reinforced because the fatigue life is so much greater than metal. They’re more likely to be able to heal their fracture before the implant fails due to fatigue,” he says in an Invibio press release. “I’ve been using the material for about two years in the proximal humerus, and I’ve been very pleased with the outcome of those patients.”

Invibio has spent more than five years developing the composite trauma plates as well as orthopaedic nails. The company, which also manufactures materials for spinal fusion devices, says that its PEEK-OPTIMA polymer is currently used in more than 5 million medical devices worldwide.

Antibacterial Walls

Infections that occur in hospitals and other healthcare facilities are a major challenge to modern medicine. The U.S. Centers for Disease Control and Prevention estimates that each year 1.7 million patients in American hospitals get a healthcare-associated infection, including nearly 100,000 patients for whom the infections are fatal. German manufacturer LAMILUX has developed a composite material to help reduce those numbers.

LAMILUX AntiBac panels, which are designed to be used in the walls and ceilings of hospitals, are made from GFRP coated with an antibacterial nanosilver that the company developed in partnership with Rent-a-Scientist, another German company. The panels provide a second defense against infection as a backup to traditional cleaning with disinfectants. AntiBac suppresses propagation of bacteria for continual protection of surfaces 24 hours a day.

Silver nanoparticles have been used in medicine since the 19th century, when colloidal silver was given as an oral medication prior to the invention of antibiotics. Today, silver nanoparticles are found in a variety of medical products, including bandages and medical devices.

“The AntiBac agent is a special, heavily modified nanosilver, which is similarly used in medicine products,” says Sascha Oswalk, product manager with LAMILUX. According to the company, the nanosilver acts on bacteria by deactivating the cellular enzymes (which hinders metabolism of the cells), destroying the cell membrane and preventing the bacteria to replicate. Oswalk says AntiBac permanently kills over 99.9
percent of bacteria within 24 hours, and the panels are designed to maintain their efficacy for more than 50 years.

The panels are produced in sheets and rolls between .6 and 5 millimeters thick. During the continuous production process, multidirectional fiberglass mats are saturated with epoxy resins and additives.

LAMILUX spent three years collaborating with scientists and healthcare professionals to develop the panels, which are currently being tested in operating room walls of the Asklepios Clinic in Bad Abach, Germany. In addition to medical settings, the company believes the panels could be used in other sectors that require strict hygiene, including the food industry.

**Composite Cartilage**

With its fibrous protein framework supporting aqueous components, human tissue is perhaps the ultimate composite. During the past three decades, tissue engineering has gained prominence as a way to create replacements for damaged or missing tissue. Tissue engineering is the practice of combining cells, engineered materials and biologically active molecules into functional tissues. Although some engineered tissues, including those for wound care, have moved into the commercial market, many others, like cartilage, remain the focus of intensive research.

Currently available engineered cartilage includes hydrogels reinforced with nanofibers, microfibers and woven or non-woven scaffolds. Non-woven scaffolds include those manufactured using 3D printing and electrospinning, a technique which uses an electrical charge to pull fibers from liquid.

None of these engineered cartilages meet the necessary mechanical or biological requirements, according to Dietmar W. Hutmacher, chair of regenerative medicine at the Institute of Health and Biomedical Innovation at Queensland University of Technology (QUT) in Brisbane, Australia, and Jos Malda, associate professor of joint regeneration at Utrecht University in the Netherlands and adjunct professor at QUT. The two lead a team of international scientists who are using a unique 3D printing technique to fabricate a new hydrogel composite that approaches the stiffness and elasticity of human cartilage.

The researchers state that although electrospun meshes have perhaps the best potential to mimic natural tissue because of their submicron fiber diameters, traditional 3D printing techniques have limited control over fiber architecture. So the researchers developed a melt electrospinning technique in direct write mode, which they say allows for layer-by-layer assembly of low-diameter fibers into a highly organized architecture.

To fabricate the composite, researchers use custom melt electrospinning apparatus to heat a medical-grade biocompatible polymer called poly ε-caprolactone (mPCL) to 103 C in a syringe. The mPCL is then extruded using a syringe pump, while an electrostatic field is created between the syringe needle tip and metal collector plate to create a stable mPCL jet. Mach3 motion control software facilitates movement of the collector plate and prints 0-90° scaffold architectures measuring up to 120 x 120 x 1 millimeters. Two 5 x 5 millimeter cylindrical samples are extracted from the scaffolds and stacked to a height of 2 millimeters, which is comparable to the thickness of human cartilage in the knee joint. Gelatin methacrylimide (GelMA) hydrogels are infused and crosslinked within the mPCL scaffolds to create a fibrous hydrogel composite, which is then seeded with human cartilage cells.

The result is a composite that approaches the stiffness and flexibility of cartilage and is conducive to cell proliferation and differentiation and ultimately, tissue regeneration. “This work is at the core of our 21st century intelligentsia in cartilage tissue engineering,” says Hutmacher.

**CFRP Wheelchair**

Paralyzed people spend most of their days in wheelchairs, so why can’t they be both functional and attractive? Carbon Black System in Nairn, Scotland, sought to design a wheelchair that met both requirements. Its new Carbon Black wheelchair uses more CFRP than any other wheelchair on the market, according to the company. It selected CFRP for many of the same reasons the material is used in sports cars: It’s lightweight, strong and stiff and can be easily molded into different shapes. It also looks sleek.

Each Carbon Black wheelchair is handmade in a facility that also produces body parts for Formula One race cars. The wheelchairs feature a high-modulus carbon fiber in a combination of woven and unidirectional prepreg fabrics. “The characteristics of the carbon fiber, linked with the unique laminate schedule, creates a strong chair with shock-absorbing characteristics,” says Paul Komoro, sales and marketing director for the company.

Depending on the features selected, the wheelchairs weigh between 11 and 18 pounds. Compare that to standard manual wheelchairs that typically weigh 35 pounds or more. The light weight has obvious benefits for users: It’s easier to push or self-propel and to lift into a vehicle.

The wheelchair’s primary components – the seat, backrest and wheels – are constructed of CFRP. The seat’s monocoque design provides the primary strength and load support as well as natural shock absorption without the weight and bulk of traditional suspension. Wheels are available in two sizes – 26 inches and 28 inches – and the backrest comes in three sizes, all of which are much smaller than traditional wheelchairs thanks to the support of the CFRP structure. Overall, the Carbon Black wheelchair has a striking, minimalistic look befitting of the company’s motto that promises “more person and less chair.”

“When you compare other wheelchairs with a Carbon Black model, you’ll find the look and feel to be completely different,” says Komoro. He adds that the wheelchairs offer “minimal aesthetic impact, but maximum maneuverability.”

Under development for more than eight years, the first Carbon Black wheelchairs were sold in the United Kingdom less than two years ago. The company would like to market the chairs in the United States, but first needs approval from the Federal Drug Administration. Carbon Black System has displayed its wheelchair at healthcare events in the U.S. and plans to open an office here in the future.

Melissa O’Leary is a freelance writer based in Cleveland. Email comments to mhx144@case.edu.
ACMA and IACMI Agreement

ACMA and the Institute for Advanced Composites Manufacturing Innovation (IACMI) have entered into a unique cooperation agreement. Both organizations recognize their complementary skills and mission to grow and foster the composites industry. The agreement outlines ways in which the two organizations will support membership development in both organizations and promote the overall composites industry. Specifically, ACMA and IACMI will align their interests to:

- Partner on workforce development efforts, including the support and promotion of the ACMA Certified Composites Technician Program (CCT).
- Agree to have IACMI present at ACMA meetings and events, and to collaborate on joint events on selected topics.
- Explore other collaboration opportunities on different topics such as composites recycling, modeling and simulation.

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North American Composites (NAC) has stocking locations across the United States and Canada providing local, personalized service to composites manufacturers. We deliver high-quality composite materials, accessories and equipment from the top suppliers. For nearly 40 years, our knowledgeable sales representatives have served manufacturers in aerospace, ballistic, construction, corrosion, energy, marine, transportation and other industrial and consumer applications.

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ACMA Testifies Before ITC

On October 14, in testimony before the United States International Trade Commission (ITC), ACMA requested an equal playing field for tariffs on composite products, covered in the Environmental Goods Agreement (EGA). The current trade system of higher outbound and lower inbound tariffs on composite utility poles and pipe provides more opportunities for foreign companies to participate in the United States market than it does for American companies to participate in foreign markets. ACMA continues to advocate for the Environmental Goods Agreement to include FRP pipes and utility poles. ACMA’s members have attempted to export composite utility poles to participating EGA member countries, but have been met with high tariffs. By contrast, other countries have much lower tariffs. Advocating for lower tariffs on composites products allows ACMA to help members become more competitive in the global marketplace.

New Members

Davis Applied Technology College
Kaysville, Utah

National Aerospace University – Kharkiv Aviation Institute
Kharkiv, Ukraine

Port of Port Angeles
Port Angeles, Wash.

Rensselaer Polytechnic Institute
Troy, N.Y.

Strategic Advisors, Inc.
Canonsburg, Pa.

University of Alabama at Birmingham
Birmingham, Ala.

University of New Hampshire
Durham, N.H.

Université de Sherbrooke
Montreal, Quebec, Canada

University of Tennessee
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For more information on becoming a member of ACMA, email membership@acmanet.org or call 703-682-1665.

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UCSC Advocates for FRP Poles

The National Rural Electric Cooperative Association (NRECA) invited ACMA’s Utility & Communications Structures Council (UCSC) to discuss composite utility poles and crossarms with NRECA’s Transmission and Distribution Engineering Committee. ACMA and NRECA discussed the advantages of FRP poles. Composites are impervious to termite damage, woodpeckers and other animals that attack wood poles. Their advantages over wood poles include ease of delivery and installation, corrosion resistance, durability and consistent long-term performance. NRECA members acknowledged the durability of FRP products, with some poles being in service over 40 years. ACMA and NRECA agreed to work together to provide education and access to design software, as well as work toward a uniform specification through the Department of Agriculture’s Rural Utilities Service. For more information, contact Dan Coughlin at dcoughlin@acmanet.org.

OSHA HAZCOM Compliance

Even though many businesses are just now adapting to the requirements of the Occupational Safety & Health Administration’s (OSHA) 2012 Hazard Communication Standard (HAZCOM), the agency’s recently announced HAZCOM enforcement policies are likely to require significant additional changes to the compliance programs implemented by many employers. Several of the enforcement policies are directly relevant to composites manufacturers. To learn the best approaches to complying with the regulation, contact John Schweitzer at jschweitzer@acmanet.org or visit acmanet.org/regulatory-compliance/workers-regulatory/2-uncategorized/174-acmanet-hazcom-manual.

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GAC Warns Against Lawsuit

During a Sept. 22 meeting, ACMA’s Government Affairs Committee (GAC) concluded the Styrene Information & Research Center (SIRC) should not proceed with legal action to prevent the listing of styrene as a “substance known to the state to cause cancer” under California’s Prop 65 toxicity warning requirement. In February, the California Environmental Protection Agency (CalEPA) proposed listing styrene as a Prop 65 carcinogen. Manufacturers of products sold in California must provide warnings if use of products could result in exposure to any of the substances listed by CalEPA as capable of causing cancer or birth defects.

SIRC is weighing whether to ask a federal court to declare the styrene evidence does not satisfy CalEPA’s definition of a carcinogen and to issue an injunction prohibiting CalEPA from listing styrene as a carcinogen. The GAC is concerned that a successful suit would only prompt the agency to find some other path to list styrene, and the resulting risk estimates would be much worse than under CalEPA’s current proposed Prop 65 styrene listing.

Preliminary data from an ongoing GAC study indicates that industry companies should be able to use exposure estimates to demonstrate that exposures associated with product use are below recognized safe levels. This would justify decisions not to apply cancer warning labels to products. For more information, contact John Schweitzer at jschweitzer@acmanet.org.
Ride like the Wind

The ability to boast the world’s fastest bike is not something Rüster Sports takes lightly. However, the Des Moines, Iowa, startup’s Dimond Bike would not have earned that distinction without lightweight materials. Rüster Sports put the Dimond through rigorous wind tunnel tests on Ironman courses and compared its performance to its two leading competitors. Its conclusion was that the Dimond’s frame gave riders an advantage at every yaw angle (wind direction). The average speed of the baseline bike was set at 25 mph.

Matt Cymanski, a manufacturing and design engineer who worked on the Dimond Bike, says the entire high-end bike industry relies on carbon fiber. He says the Dimond was able to reach optimum speed because Rüster Sports used composites to customize the bike frame’s aerodynamic shape, or “airfoil.” Cymanski says designers can make a decent airfoil with other materials, but Rüster Sports saw CFRP as the best option.

“[With CFRP], you can change your airfoil as you go throughout the bike, whereas if you’re going to make it out of steel or aluminum, for example, you might get an airfoil shape, but it’s going to be the same cross section the whole way down,” Cymanski explains. “You just lose a lot of performance if you don’t make it out of carbon fiber.” According to Rüster Sports’ website, production of every Dimond bike starts with plies of unidirectional polyacrylonitrile-based carbon fiber, pre-impregnated with catalyzed polyepoxide resin. Cymanski explains Rüster Sports went the prepreg route due to its relative convenience compared to a wet lay-up or vacuum infusion process. The thickness of each ply stack varies depending on where it goes on the frame. Some areas are just a few plies of prepreg, less than one millimeter thick, while other areas are almost ten times as thick.

“I think our thinnest part is probably about four plies,” Cymanski says. “There’s a couple of parts that are actually compression molded … and those parts are 50-plus plies.” After the plies are cut, they are folded in an aluminum mold and cured. For most of the parts, Rüster Sports uses a bladder molding process out-of-autoclave.
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The Composites and Advanced Materials Expo – CAMX – is seeking high-quality technical papers and education sessions featuring new research and applications.

Interested candidates must submit a 250-word abstract detailing the proposed paper/presentation by March 1, 2016. Authors and presenters of accepted papers and presentations receive discounts on CAMX registration, and are published in the CAMX proceedings. Visit www.theCAMX.org/call-for-abstracts for more information.

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