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Features

A Market with Staying Power ................................................ 14
Composites are an appealing solution to utility companies trying to solve the tricky issue of grid failures. Discover how manufacturers and utilities partner on projects for poles, crossarms and other applications. Plus, an update on the Environmental Goods Act.
By Megan Headley

Thinking Big .......................................................................... 20
Industry breakthroughs abound, from additive manufacturing to automated production and precise machining. Composites manufacturing is making large-scale advances thanks to collaboration among industry, universities, government agencies and others.
By Mary Lou Jay

Serving Up Cores for Sandwich Composites ....................... 26
Developments in core materials are opening up opportunities in aerospace and automotive as they allow for high-volume production. Check out what’s new from several suppliers.
By Patrice Aylward

About the Cover:
Hexapod robots carrying vacuum grippers on an R&D station for automated panel assembly at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM can shift, tilt and rotate a part – as well as adjust its shape – according to precise requirements.
Photo courtesy of Fraunhofer IFAM.
As we approach the close of the first quarter of 2016, it’s a good opportunity to reflect upon some of the great things happening in our industry. Composites are gaining traction across market segments in part because of advances in manufacturing. The cover story on page 20 of this edition of Composites Manufacturing discusses several industry innovations that are making manufacturing faster, more efficient and more cost-effective.

Ultimately, those advances benefit our end user customers across niche markets, from aerospace to marine. One area where composites are poised to grow by leaps and bounds is the utilities and communication structures segment. In the article “A Market with Staying Power,” ACMA member companies share how they are helping utility companies strengthen the electrical grid. The story on page 14 also includes an update on ACMA’s grassroots efforts to include FRP composite utility poles and crossarms in the Environmental Goods Act. Another feature article looks at the efforts of some suppliers to improve core materials to meet today’s requirements for bonded sandwich structures.

All three of these articles – on manufacturing, market segments and materials – point to changes in the industry that may not have been considered possible just a few short years ago. Our members and ACMA are driving those changes.

We live and work in a very dynamic environment. The only constant we can count on is change, and being prepared for these changes will help you be successful in your business. I hope you will agree this edition provides great insight into the exciting work going on in the composites industry.

ACMA is actively engaged in much of this work and continues to bring great value to our members. We invite you to join us in identifying and driving the composite applications of the future. And when you’re involved in an innovation, email Composites Manufacturing magazine’s Managing Editor Susan Keen Flynn about it at sflynn@keenconcepts.net. Sharing our individual successes is another way to promote composites and grow the industry as a whole.

As always, thank you for your support of ACMA. Your contributions are what makes our industry so strong.

Jeff Craney
ACMA Chairman of the Board
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Join us today! Contact ACMA’s membership department at 703-525-0511 or membership@acmanet.org. Learn more at www.acmanet.org.
How to Use Fire Tests to Design Fire-Safe Composites

By Nicholas A. Dembsey

FRP composites are used in a range of industries such as aerospace, automotive, building construction, infrastructure, and marine and rail passenger transport. FRP materials are attractive to those industries for many reasons, including their high strength-to-weight ratio, ability to be molded into unitary shapes, flexible aesthetics and durability. However, composites have been limited in some applications because of concerns with flammability. All of the above mentioned industries have fire safety regulations for material systems such as FRP.

As the composites industry grows and new applications are developed, it’s important to have a basic understanding of fire safety regulations and fire testing.

The Role of Fire Tests

Fire safety regulations aim to achieve passive and active protection. Passive protection involves two performance requirements: reaction to fire (fire spread) and fire resistance (compartmentation). Reaction to fire is also called fire, smoke and toxicity (FST). A material system and its assembly with good reaction to fire performance will not spread fire beyond the location of fire origin. It will produce low levels of heat release rate and low levels of smoke and toxic species production rates when exposed to a local thermal insult.

As the composites industry grows and new applications are developed, it’s important to have a basic understanding of fire safety regulations and fire testing.

Using the Fire Testing Paradigm for Design

In general, there are four components to the fire testing paradigm: micro-scale, bench-scale, intermediate-scale and full-
scale tests. Micro-scale tests are used by material suppliers to characterize their resins and additives. Bench-scale tests are used by suppliers and manufacturers to characterize materials system performance. Intermediate-scale tests are used by manufacturers to characterize assembly components. Full-scale tests are used by manufacturers to characterize assemblies.

Costs increase substantially from micro-scale and bench-scale tests to full-scale tests. Given that fire regulations rely heavily on intermediate-scale and full-scale tests, significant cost is involved in demonstrating the required performance. To minimize this cost, manufacturers need to understand how micro-scale and bench-scale fire tests can be used to predict results from intermediate-scale and full-scale tests.

Micro-scale tests such as Thermogravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC) are used to determine key resin and additive characteristics, including the thermal decomposition temperature and the energy of decomposition. Understanding these characteristics allows manufacturers to develop different candidate FRP composites (material systems) based on quantified data. The bench-scale test Cone Calorimeter (Cone, ASTM E1354) can then be used to measure key material system characteristics such as time to ignition, burn duration, heat release rate per unit area (HRRPUA) and smoke production rate (SPR). The performance of candidate FRP composites can then be evaluated in terms of these characteristics.

An important attribute of the Cone is the ability to change the thermal insult (incident heat flux) applied to specimens. This allows the Cone to “scale” – or approximate the thermal insults of intermediate-scale and full-scale tests. By matching the thermal insult of a given test, characteristics such as HRRPUA and SPR can be used to predict behavior in these larger scale tests. These predictions are typically based on correlations and/or simple empirical models. It is important to understand that the Cone provides key understanding of material system behavior but does not provide complete understanding of component or assembly behavior.

Component and assembly performance depends not only on material system performance but also on the geometrical integrity of the component or assembly. Geometrical integrity is demonstrated by the component or assembly parts working together to maintain geometrical stability while under thermal insult (fire exposure). A key part of maintaining stability is the use of material systems which limit fire spread when either the component or assembly is exposed to fire. This is the basis of how the Cone can be used to predict behavior in larger scale tests. Using the Cone to predict intermediate-scale and full-scale behavior limits the number of tests that need to be run to demonstrate performance requirements of fire regulations.

A Closer Look at One Industry

As an example, let’s consider FRP composites for building construction. The relevant fire regulations are the International Building Code (IBC) as amended locally by states and cities in the United States. The IBC 2009, IBC 2012 and IBC 2015 all have specific reaction to fire performance requirements for FRP composites. No specific FRP composites fire performance requirements for fire resistance are written into the IBC at this time. Fire resistance of FRP composites and their assemblies is handled consistently with other materials such as wood, metal and concrete. The way roofing performance of FRP composites and their assemblies is handled is consistent with other materials.
The reaction to fire performance requirements for FRP addressed in the IBC are for the following applications: interior finish, light transmitting materials and exterior use. The key fire tests for interior finish are ASTM E84 and NFPA (National Fire Protection Association) 286. The key fire tests for light transmitting materials are ASTM D1929, ASTM E84, ASTM D2843 and ASTM D635. The key tests for exterior use are ASTM E84, NFPA 285 and NFPA 268. The fire resistance performance requirements addressed in the IBC are substantially based on the fire test ASTM E119, while the roofing system performance requirements are largely based on the fire test ASTM E108.

Other than the bench-scale tests used to evaluate light transmitting materials, all reaction to fire applications as well as fire resistance and roofing system applications covered in the IBC require intermediate-scale to full-testing to demonstrate performance. The use of intermediate-scale and full-scale tests for FRP design and the use of full-scale tests for assembly design are prohibitively costly.

How then can we use the noted fire testing paradigm to design fire safe FRP composites that comply with IBC requirements? Manufacturers should engage with their materials suppliers to understand resin and additive performance based on micro-scale testing such as TGA and DSC. Although these tests are not required by the IBC, they can provide key characteristics of resin and additives that can inform the FRP design process. Candidate FRP composites can then be designed and tested in the Cone at the appropriate incident heat fluxes. These results, in turn, can be used to predict how the FRP candidates will perform as part of components and/or assemblies in the required intermediate-scale and full-scale IBC tests. Use of the Cone combined with predictive tools that use characteristics measured in the Cone for FRP design will limit the number of intermediate-scale and full-scale tests needed to demonstrate performance required by the IBC.

The guest columnist for this issue’s “Best Practices” column is Nicholas A. Dembsey, PhD, PE, FSFPE, a professor in fire protection engineering at Worcester Polytechnic Institute in Worcester, Mass. Email comments to ndembsey@wpi.edu.
Aerospace

Light-Sport Aircraft Made from CFRP

If you want a better plane, start with a better material. Then combine that with innovative processing and design. That’s the thinking behind production of the world’s first completely vacuum infused CFRP single-engine, light-sport aircraft, according to Naresh Sharma, CEO of NASHERO. Based in San Giovanni in Croce, Italy, the small startup company was launched in 2010 and offers business and engineering consulting as well as high-precision composite and metal prototype fabrication. The aircraft – its first product – is not your run-of-the-mill recreational plane.

“The first aircraft design is a high-performance, two-seat full carbon light aircraft that is designed for the pilot-owner as a means for traveling safely from A to B with comfort and ease,” Sharma says. “To us, high performance implies extremely low fuel consumption for the distance travelled and extremely low environmental impact. Our aircraft, on a per seat mile basis, has significantly lower emissions compared to low-emission hybrid automobiles.”

The plane also features high-end safety features. These include a safety cell design, allowing the aircraft to take a frontal crash with minimal transfer of impact energy to the pilot or passenger. A second safety element is an integrated aircraft ballistic parachute recovery system – essentially a parachute for the entire plane – embedded in the fuselage.

The choice of materials and fabrication technique was critical to achieve the desired performance. Aluminum alloys are typically used to construct small aircraft, but composites offer several advantages. These include lower weight, corrosion resistance, high fatigue strength, high stiffness for increased flutter resistance, superior crash-absorption capabilities, the ability to produce sculpted shapes and the potential for better aero-elastic tailoring of flying surfaces. NASHERO opted for CFRP because it enables creation of the stiffest and strongest structure, while remaining lightweight. A lighter overall structure accommodates a lighter engine and a larger payload.

Nearly all of the airplane’s structural parts are composed of CFRP. One exception is the engine mount, which by regulation must hold its strength to temperatures above 1000 C. In addition, areas where a load must be transferred from one part of the structure to another use metal, such as aluminum and titanium embedded as hard points between layers of reinforcement fibers.

NASHERO selected a range of CFRP materials for the light-sport aircraft, including regular woven hybrid aramid-carbon twill, unidirectional tape, multi-axial spread tow stitched fabric and spread tow carbon fiber fabric up to 24K filaments. By its nature, the fiber itself is free of internal defects, says Sharma. In addition, crack propagation from one fiber to another is difficult. That combination makes the fatigue life of CFRP almost infinite, Sharma says.

The key to developing a very strong overall structure lies in getting rid of voids that may form in the epoxy resin. NASHERO guarantees the lowest void content in its composite matrix structure thanks to a proprietary vacuum infusion process. “This also lets us get ideal fiber volume fractions depending on the interstitial gaps in the reinforcement stack,” Sharma says.

That process, and the engineering
behind it, attracted the attention of R&M International, a supplier of textiles and plastics in Fort Washington, Pa. After evaluating NASHERO’s technology, R&M teamed up with the company in late 2015 to produce high-quality CFRP parts for sale in the United States.

According to R&M Partner Stephen Rawson, the NASHERO process features other impressive innovations aside from the low void content. One is its closed loop material management system that protects workers and the environment from the risks associated with chemicals and airborne fragments. It also reduces material scrap, which saves money.

“NASHERO was able to reduce chemical waste down to percentage levels below two percent, whereas some sectors of the industry have percentages as high as 30 percent that ends up as production waste,” Rawson says.

Another innovation is the use of high-efficiency curing ovens to produce parts. The resulting components equal the quality usually only seen at large aerospace firms, according to Rawson. Sharma says the company developed its proprietary ovens out of necessity, as an extensive search-and-bid process involving multiple vendors failed to turn up anything suitable. NASHERO’s ovens measure 27.9 x 8.2 x 8.2 feet, enabling the curing of large airplane parts. They can hold a temperature differential of 230 F while consuming a tenth of the energy of the most other ovens, Sharma says.

He also notes that vacuum infusion for aerospace components requires care since it’s difficult to place dry fabric on inverted surfaces. Adhesives can’t be used because that would lead to impurities and potential defects. The company overcame this challenge through design and process adjustments.

As of early 2016, most of the primary structure of NASHERO’s plane is complete. Assembly and system integration is now underway, with flight testing soon to follow. The company’s current facility can support production of about 20 aircraft per year. After flight testing, NASHERO plans to move to a larger plant capable of manufacturing more than 200 aircraft annually. The new building will facilitate NASHERO’s long-term plans to produce three models of the aircraft, with at least one constructed with less expensive fiberglass composites.

Hank Hogan is a freelance writer based in Albuquerque, N.M. Email comments to hank@hankhogan.com.

For more stories like this, visit CompositesManufacturingMagazine.com and check out the Aerospace articles under the “Market Segments” tab.
Building a Storm Proof House

Mindful of the damage Hurricane Sandy inflicted on coastal New Jersey in 2012, students from Stevens Institute of Technology in Hoboken, N.J., didn’t just design the 2015 Department of Energy’s Solar Decathlon winning “SURE HOUSE” to be ultra-energy efficient, but also utilized composite shutters and hatches to help make the home storm proof.

“In addition to following all the rules of the competition, which have to do with [building and designing] a zero energy, solar-powered house, we wanted to take the definition of sustainable to a completely new level, which included resilience through storm protection,” says Tom King, one of six team members from Stevens’ master’s degree program in product architecture and engineering.

King worked for Aquidneck Custom Composites, a custom boat builder in Bristol, R.I., after he finished college and completed a post-graduate composite fabrication course at the International Yacht Restoration School in Bristol. The team was able to use King’s experience to incorporate composites in the house. Initially, they explored using GFRP for the entire structure, creating “a boat that would be a house,” recalls King. But the team ran into problems with building and structural codes. “There is no real guideline for how to design a composite for a residential home,” says King. “We wouldn’t have been able to do all the proper testing to prove that the house was structurally sound, so we abandoned that idea due to time constraints.”

Instead, the team used a traditional wooden frame filled with mineral wool insulation and covered in plywood, designed to Passive House Institute standards that aim to significantly reduce energy consumption. The exterior walls and underside of the floor were then dry flood proofed — or made watertight below the level that needs flood protection — by attaching ⅛-inch thick 4 x 8-foot sheets of GFRP.
of acrylonitrile butadiene styrene (ABS) to the plywood with gasketed roof screws. All the joints were then sealed with a marine sealant from 3M™ and a layer of Vycor® waterproof tape.

Once the structural flood proofing design was complete, the team from Stevens’ worked with Gurit (USA), Inc. to design GFRP shutters and plugs to protect the home’s windows and doors from flood waters. The biggest challenge was designing shutters for the sliding doors on the house’s south side. The house required six sets of bi-folding shutters, measuring 10-feet, 7-inches tall by 7-feet, 5-inches wide. They had to be light enough to easily pull down and lock in place over the sliding doors in case of a storm. GFRP was the obvious solution. “We knew fiberglass was a great material because of its economic price point, and we also knew that we needed something that was high strength and lightweight” says King.

Laminate schedules were developed and tested using full-scale prototypes to determine the most durable and lightweight design. These prototypes and the final panels were fabricated at Aquidneck Custom Composites (ACC). The top and bottom panels were laminated in pairs on the flat table mold. The bottom panel, which needs to withstand loading from flood waters and impact from floating debris, was designed for more strength and impact resistance than the top panel. The Stevens’ team and ACC produced two prototypes, tweaking the materials and conducting finite element analyses at Gurit, before settling on the right solution.

The bottom panel features a 1.5-inch PVC structural foam core from Gurit for added strength and impact resistance, a single layer of Vectorply biaxial E-glass aligned ±45° and an outside layer of Vectorply triaxial E-glass aligned ±45/90° to reduce deflection. To save weight and reduce cost, the top panels – which carry a solar panel and are subject to wind and snow loading – were fabricated with a 1.5-inch high-density polyisocyanurate core cut at Polycel Inc. and two layers of Vectorply biaxial E-glass, the first oriented at ±45° and the second at 0/90°.

The team strengthened the mounting locations for critical hardware, such as the shutters’ marine latches, with 24lb./ft.³ glass fiber reinforced core and additional localized laminate. Both panels used a gel coat from Polymat Composites and a Vectorply .75-ounce chopped fiber mat for the skin coat and were vacuum infused with a vinyl ester resin from Polymat Composites. Once gelled, the resin cured for 12 hours, allowing for fabrication of about one pair of shutters per day. The panels were then sanded and polished to marine finish quality. Each two-panel unit weighs approximately 180 pounds.

For now, SURE HOUSE remains near the Solar Decathlon site in Irvine, Calif., awaiting shipment to a not-yet-determined east coast location. Wherever it lands, King says the house will serve as an exhibition for schools, industry and others to learn about sustainable, low-energy building practices and dry flood proofing techniques. In addition, he believes that widespread construction of hyper-energy efficient homes is right
around the corner. “The way in which residential construction will be built in the very near future is the way we built our house,” he says. “It’s a way that residents can save a lot of energy, reduce their footprint and also live in a house that costs a lot less to run.”

As for the home’s innovative floodproofing, King hopes that SURE HOUSE will be a step toward a new type of street-level storm resilient house that is acceptable to the Federal Emergency Management Agency and the National Flood Insurance Program. “We have worked to create a practical and real solution to storm resilience,” he says. “Rather than leveling the house and rebuilding it on stilts – the typical technique now – the house that we designed can survive a storm event and be lived in afterward.”

Melissa O’Leary is a freelance writer based in Cleveland. Email comments to mxh144@case.edu.

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The 273-mile-long Illinois River is a primary tributary of the Mississippi River and part of an important waterway connecting the Great Lakes to the Mississippi River. Barges transporting goods ranging from grain to oil traverse the waterway thanks in large part to several locks and dams managed by the U.S. Army Corps of Engineers (USACE). In August, GFRP wicket gates were installed on one of those navigational structures – the Peoria Lock & Dam on the Illinois River at Creve Coeur, Ill.

"Maintaining waterway navigation is a big part of what the Corps of Engineers does for our nation," says Rich Lampo, materials engineer with the U.S. Army Corps of Engineers, Engineer Research & Development Center (ERDC) in Champaign, Ill. "But a lot of navigational structures have far exceeded their original design life. Our mission is to investigate the use of fiber-reinforced polymer materials to help maintain and replace aging components."

That mission is critical considering that 95 percent of the dams managed by the USACE are more than 30 years old and 52 percent have reached or exceeded the 50-year service lives for which they were designed. According to the USACE website, it would cost $24 billion to fix all the dams that need repairs.

In 2011, the ERDC began partnering with West Virginia University (WVU) to investigate low-maintenance, corrosion-resistant composite components for locks and dams that lower life cycle costs. They began by designing, testing and implementing recess filler panels and wicket gates – low-risk applications that could demonstrate the potential use of composite materials in navigation structures. Recess filler panels are used in locks with emergency lift gates to fill in the area in the lock wall when the emergency gate is lowered. Without the panels, vessels passing through the lock could hit and damage exposed corners of the wall. Wicket gates help maintain a navigational pool in the river. The gates rest on the bottom of the river and are raised when the water gets too low.

Hota V. GangaRao, a civil and environmental engineering professor at WVU and director of the Constructed Facilities Center, is one of the investigators on the project. GangaRao began work on composites in 1987 and teamed with the USACE on three projects related to roadways and bridges in the 1990s. Work on those projects served as a building block for the lock and dam structures, which are typically made from wood, concrete or steel. "We are the first ones to implement GFRP-based products for navigational structures in the United States," says GangaRao.

He cites several reasons why GFRP is ideal for lock and dam components. First, the material is corrosion-resistant, which lowers maintenance costs. "The more maintenance you have, the more delays in the navigational system," says GangaRao. Locks shut down during maintenance, which can cause thousands of dollars in lost productivity.

In addition, GangaRao felt that WVU could design and install some navigational structures at a lower initial cost than existing materials. Some of the structures require very large timber, and GangaRao says it’s much more difficult to obtain quality wood in those sizes than it was 30 to 50 years ago. "We hope that using GFRP can reduce both initial and life cycle costs," he says.

WVU began by investigating...
Three GFRP wicket gates were installed on the Illinois River last August to help maintain a navigational pool in the river.

Options for recess filler panels, which are traditionally made of welded steel I-beams, angles and plates. This makes them heavy to lift and susceptible to corrosion. University researchers developed and tested four different FRP recess panel designs, then partnered with Creative Pultrusions in Alum Bank, Pa., to fabricate the one that performed best – a hexagonal FRP superdeck system.

The company pultruded three prototype recess filler panels that are 10 feet long, 12 inches wide and 8 inches thick and include a top surface coating from Rhino Linings®. The panels use a vinyl ester resin and more than 30 layers of fiberglass fabric, including 0°/90° and 45° fabrics. “The fiber orientation is extremely complicated,” says GangaRao. “We are making sure the panels have enough shear capacity as well as enough bonding strength.” The panels have been delivered to the Willow Island Locks near Newport, Ohio, and should be installed this spring.

Next, WVU worked with the USACE to design GFRP wicket gates measuring 16 feet long, 4 feet wide and 8 inches thick. The composite design is corrosion-resistant and provides equal or better mechanical properties than a wooden wicket gate. It’s also compatible with the original hardware, which makes it easier to replace and operate the gate. Composite Advantage in Dayton, Ohio, fabricated the gate using vacuum-assisted resin transfer molding (VARTM). The gates underwent various bending tests at WVU, then the engineers made some design modifications. For example, they added an ultra-high molecular weight polyethylene layer on the face of the wicket gates to help prevent abrasion and ice damage.

The gates, installed last August on the Illinois River, are working well so far. They will be pulled from the river and inspected this summer. Equally important to their performance is the anticipated cost savings for the two locations on the Illinois River using wooden wicket gates. “Because of the extended lifetime of the composite gate versus a wooden gate, as all of the wooden wicket gates are changed over, we calculate a savings of almost $19 million over a 50-year lifetime,” says Lampo. “We’re hoping that will kick start interest in the use of composites for other more demanding lock and gate structures.”

With approximately 87,000 dams listed in the National Inventory of Dams, which is maintained and published by the USACE in conjunction with the Association of State Dam Safety Officials, there certainly is a lot of potential for FRP materials. The floodgates are open for composite solutions.

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

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Despite its light weight and hollow form, this composite pole easily supports more than two tons of transformers.

A Market with Staying Power
Since the United States began moving from localized electric distribution to bulk transmission nearly a century ago, there have been relatively few widespread infrastructure changes. Today, however, it’s become increasingly clear that the technology exists to replace aging and problematic infrastructure, prevent the massive grid outages seen across the country in recent years and support new utility offerings — and consumers expect to see solutions put in place.

GFRP utility poles have been used since the 1960s when the first fiber-reinforced polymer transmission structure was erected in Maui, but today several factors are pushing utilities to expand the use of more reliable alternatives to traditional products.

Putting Power Outages in the Past

While wood poles – the workhorse of the electric utility – have a predicted 30-year life expectancy, many have been in service upward of 80 years. Replacement typically comes only after a pole is damaged, but it’s easy to understand why utilities have operated on a “run to failure” model. An electric company might have tens of thousands of poles in its jurisdiction, and replacing every component on a regular cycle would take significant time and money.

High Plains Power Inc. in Riverton, Wyo., for example, has more than 80,000 poles in its service area. “That’s a lot of line to look at,” says Sid McDonald, manager of operations and engineering for the company. “We’ve got a 75-year-old system, and a lot of stuff needs to be upgraded. … We look at lines, and if they’re starting to show some age we go in and redo a section at a time.”

Because wood is susceptible to damage from rot, woodpeckers and weather, many states have mandated periodic inspections of their utilities infrastructure. However, not all utilities can be proactive on this front. As Steve Long, manager of engineering for United Electric Cooperative in central Pennsylvania, notes, “I am not sure what our ‘standard’ rate of replacement for poles is. We do have poles still in service that were set in the 1940s.”

Today, however, waiting for failure has become unacceptable to both consumers and state Public Utility Commissions (PUCs). Since alternatives to wooden electric components show promise, the PUCs want to see grid failure become a problem of the past.

The issue of grid failures gained media attention in 2011 when windstorms swept through Southern California, knocking over transmission lines that ultimately started a fire in one county and major power outages in others. Then, in 2012, Hurricane Sandy left more than 8 million electric customers along the East Coast without power. The severity of these incidents, as well as several straight line wind events leading to outages throughout the Midwest, prompted PUCs to take a closer look at the electric grid and ask how these failures could have been prevented.

Years of investigations have led some PUCs to demand new “non-wood” infrastructure solutions. “The PUCs have said to the utilities that they either need to develop a plan to make their infrastructure more robust so we don’t see these massive failures, or they need to submit a plan for improvement that will then allow for additional costs in their rate base,” explains Scott T. Holmes, director of business development for Highland Composites in Statesville, N.C., and chair of ACMA’s Utilities & Communications Structures Council.

In other cases, utilities are coming to this conclusion themselves. For Appalachian Power Co. (APCo) in Charleston, W. Va., snow damage led to the initial switch to composites. A very wet snowstorm in December 2009 caused extensive damage, including approximately 1,000 broken utility poles. “Many of these poles were located in very rough terrain. Getting heavy equipment to some of these locations was almost impossible,” says Tim Brammer, senior electrical engineer for the company.

APCo began using helicopters to transport poles to these remote locations, but was limited to a 1,000-pound lifting capacity. “This weight limit meant that we could only lift and set a 35-foot class 4 or 5 pole,” he adds. “Often we needed a taller and stronger pole at some of these locations, but the weight kept us from using a standard size helicopter [to install them].” (Utility poles are divided into ten classes, indicating the circumference of the pole: the higher the class number, the skinnier the pole.)

To solve the problem, the company began using INTELLI-POLE® modular utility poles from Highland Composites in 2012. It’s much easier to install the 850-pound modular sections than traditional wood poles. “By using the INTELLI-POLE, we can now set a 45-foot class 1 pole with a standard, lower-cost helicopter,” Brammer says. So far, the utility has replaced approximately three dozen wood poles with GFRP ones, and it’s considering expanding the use of composites.

“We are currently conducting a cost comparison study between the wood and composite pole set in rough terrain. This will determine the actual savings. This savings will help us justify using more composite poles,” Brammer says.

Despite their higher upfront costs, composites are gaining acceptance as a solid choice for hardening infrastructure across the utilities and communications infrastructure market.
the country. These products’ light weight, long life, corrosion resistance and low conductivity are all significant benefits compared to the alternatives of wood, steel and concrete.

“It used to be that our challenge was convincing prospects that fiberglass is a superior alternative to wood,” says Dean Casad, vice president of product and marketing for GEOTEK in Stewartville, Minn. “Now it seems that prospects are pre-sold on fiberglass and coming to us for help making the switch.”

One of those companies is High Plains Power, which sought out GEOTEK when it needed to replace wood crossarms on H-frame transmission structures. The company already used GFRP products for distribution lines and felt confident that GEOTEK’s PUPI® products could meet its demanding needs. High Plains Power installed PUPI crossarms, which feature a polyurethane foam fill, along 100 miles of a heavy-duty transmission line in a region known for its harsh weather and tough terrain.

Motivation to Move to Composites

According to Casad, crossarms – those horizontal supports actually holding the power lines – are the component seeing the biggest shift from wood to GFRP. “The big competition is still the traditional materials of construction, i.e. wood,” says Dustin Troutman, director of marketing and product development for Creative Pultrusions in Alum Bank, Pa. “Wood still dominates the crossarm market, especially the power pole market, from a distribution level – [but] wood is losing a lot of market share.”

Indeed, over the last seven years, High Plains Power has gradually switched almost 100 percent of its 80,000 crossarms to GEOTEK’s PUPI crossarms. “We no longer even use wooden crossarms,” says McDonald.

For APCo, the biggest benefit offered by composite crossarms is their strength-to-weight ratio. Typically, on dead-end towers, which serve as a heavy “anchor” along transmission lines, the company uses two 9-foot wooden crossarms. “Each arm weighs approximately 90 pounds, which is a lot of weight for the line mechanic to handle off a set of hooks. One 10-foot heavy-duty fiberglass arm, weighing only around 80 pounds, can take the place of two 9-foot wooden arms,” Brammer says.

While United Electric typically does not use GFRP poles due to the upfront price, there are areas where the cooperative can’t deny that the benefits outweigh the cost. For instance, the utility company relied on GFRP for pole structures in a critical valley crossing to prevent woodpecker damage. “We had two three-pole structures on either side of a 1,600-foot valley crossing that the woodpeckers kept attacking,” says Long. “Patching and bird deterrents did not work, so in came fiberglass.”

As composite products prove their worth over alternatives, electric companies aren’t the only utilities recognizing these advantages. “Some of the biggest change we are seeing on the West Coast is a major push from local utility entities specifying the use of polymer enclosures over concrete. These enclosures primarily house water meters, cable company connections, power connections and sewer components,” says Mark Yoakum, polymer concrete manager for Jensen Precast in Las Vegas. “Polymer’s inherent nonconductive matrix and the ability to retain a coefficient surface much longer is a major factor in their decision.”

Yoakum sees this push toward composites use coming from the rapid deterioration of cement products and concrete’s inability to resist freeze/thaw environments. “Prior to composites being better known, the choices were concrete in a coastal area or steel,” says Holmes. “Concrete will work, but in a coastal environment eventually you’re going to have breakdown and corrosion to deal with.”

Breakdowns can no longer be afforded by problem-plagued utilities. “Composites are competing by providing solutions that are extremely reliable and long-lasting. System hardening is a priority for many of those switching to fiberglass crossarms,” Casad says. And, he adds, these competitive products virtually sell themselves. “Much of our promotion is in the form of satisfied users talking to their colleagues. Electric utilities are big on sharing best practices.”

Gaining Legitimacy in the Marketplace

Of course, as Holmes points out, “You always have to sell.” And so rather than waiting for the electric utilities to arrive at the conclusion that composite components can help solve reliability challenges, manufacturers are also actively promoting the legitimacy of their products as a strong option. In just over a year, ASTM International committee D20.18 on Reinforced Thermosetting Plastics drafted and published ASTM D8019, Standard Test Methods for Determining the Full Section Flexural
An Update on the Environmental Goods Agreement

By Dan Coughlin

For a year, ACMA has been active in negotiations related to the Environmental Goods Act (EGA), which strives to cut tariffs on environmental goods. In March 2015, ACMA’s Utility & Communications Structures Council (UCSC) decided to pursue the inclusion of FRP composite utility poles and crossarms in the EGA being negotiated through the World Trade Organization in Geneva. I traveled to Geneva in May 2015 to represent ACMA and build support for the first step, which is to be nominated.

The first task was to build the case including FRP utility poles and crossarms under the category of Environmentally Preferred Products (EPP) to prevent contamination of soil and groundwater, limit human exposure to hazards and reduce hazardous waste. Over 5 million wood poles are replaced every year, creating a large amount of chemically-treated waste. Unlike treated wood poles, composite poles are environmentally inert.

In September 2015, FRP utility poles and crossarms were nominated by Chinese Taipei (Taiwan) to be included in the EGA. The following month, ACMA testified before the U.S. International Trade Commission (ITC), an independent federal agency that provides trade expertise to both the legislative and executive branches. ACMA’s testimony, based on input from members of the composites industry, supported elimination of tariff barriers for FRP utility poles and crossarms.

A significant side benefit to this testimony is that FRP composites are being recognized for their environmental advantages. This benefits the entire composites industry – especially those market segments where governments have a stake in procurement, such as state-owned utilities and infrastructure.

Now that composites have been nominated for inclusion in the EGA, the next step is to build support to include them in the final agreement. In December 2015, ACMA staff joined the Coalition for Green Trade in Geneva to answer questions about the nomination from the 17 EGA countries. The Coalition for Green Trade is a network of businesses in the U.S. who are working to increase exports of U.S. produced products, including GE, Walmart and Honeywell. A strict timetable has not been set, but it is hoped that the EGA agreement will be finalized in late 2016.

Dan Coughlin is vice president of Composites Market Development for ACMA. Email comments to dcoughlin@acmanet.org.

Modulus and Bending Strength of Fiber Reinforced Polymer Crossarms Assembled with Center Mount Brackets.

“A standard does two things: first it legitimatizes your materials. It takes the hearsay out of it,” says Troutman, who chaired the standard-writing committee. “Second, everyone speaks the same language when you have a standard. The person using the product knows exactly how it’s being tested, and the person manufacturing the product knows how to test it. So it reduces any type of miscommunication. That protects both the end user and the manufacturer.” The standard, now available through ACMA at acmaeducationhub.org, formalizes the product test procedures and how to report findings. (ACMA’s Utility & Communications Structures Council is now working with ASTM on a standard for utility poles.)

Creating a standard is a significant first step, one with great support from composites manufacturers and end users, says Troutman, who spearheaded the effort to draft and complete the standard on crossarms. Ensuring this standard is used is the next step in moving composites further in this market segment. “The industry could benefit from additional standardization efforts and inclusion of these products in such places as building codes, electrical codes and other application standards,” Yoakum says.

Emerging Markets to Watch

It’s a good time for composites to make the utilities industry sit up and take notice, as there are significant opportunities for growth here. The PUCs’ demand for improvement is just one prompt pushing change.

“Polymer wastewater infrastructure components are among the biggest changes we are seeing, with a shift in the market to a lighter, stronger and [more] chemical-resistant product that requires little to no maintenance,” Yoakum says.

In the electric industry, composites are primarily being used in distribution lines, the relatively low-voltage segment that delivers electricity to consumers. The transmission segment – the higher voltage segment carrying electricity across longer spans such as from grid to city – remains an opportunity for significant growth. Casad notes that there are some challenges to overcome first. “The selling process is different in transmission because there is much more application engineering and customization required,” he says. He adds that this has increased the importance of GEOTEK’s application engineering resources.

In addition, there are related applications emerging in the telecommunications industry. “Possibly the greatest changes for the use of these products is the emergence and growth of the fiber optic telecommunications systems,” Yoakum says. “The use of fiber has progressed from long distance transmission lines to loop systems around major metro areas to fiber distribution into neighborhoods. Currently, these fiber networks are being extended to the curb and to the home, allowing vast amounts of information to be transmitted and accessed from businesses and homes.” Today, Yoakum says, most of the fiber optics lines needed to supply these applications are spliced underground in polymer concrete enclosures.

Holmes sees more telecommunications opportunities above ground. “We’re trying to support the utilities where they want to have third-party telecommunications companies attach into their pole,” he says. “In a lot of cases this has driven utilities to increase the load capacity of their poles.”

When the windstorms swept through California in 2011, overloading was a major factor contributing to downed utility...
Linemen are pushing development of next-generation composite crossarms and braces, as product manufacturers develop strategies for easing installation.

Telecommunications companies had attached scores of phone and cable lines in densely populated areas. "Those poles were put in a long time ago, and over time they're supposed to reevaluate the loads on the poles as they attach more wires for telecommunications," says Holmes. "But something broke down in this process on the telecommunications side, so a lot of these poles failed at that location when the storms came through."

As a result, utilities are looking at increasing their load rating to the next grade for stronger poles. Taller poles also are appealing, since they present more real estate for bundling in telecommunication lines.

Holmes also is watching the potential for new infrastructure as the country moves more aggressively toward solar power. Larger utilities are being mandated to support a certain percentage of their power production with diversified energy resources, while some states are enacting legislation to increase use of solar. "They're going to have to set up new networks to tie into these solar networks, and that will be a combination of both transmission and distribution lines," Holmes says. And like solar itself, composites promise a sustainable, reliable alternative to existing options.

**Improving on Today's Product**

To best take advantage of these opportunities, composites manufacturers are aiming to sell their products not on reliability alone, but on ease of use as well. As Casad points out, "Electric utilities are often short-staffed. We can help drive penetration by making adoption easy for engineering staffs that are working to keep their heads above water."

Ease of installation is a significant concern for utilities dealing with upgrades in remote locations and difficult to access backlots. Long points out that the main reasons his Pennsylvania cooperative has been using fiberglass crossarms for dead-end towers for the last 20 years or so "is for their clean installation [no braces]."

"Linemen are often skeptical of switching from wood to fiberglass, but once they do, they become our biggest advocates," Casad finds. He says that installers appreciate that GFRP crossarms assemblies are typically pre-assembled.

Holmes adds that the ability for linemen to hand carry composite poles weighing approximately 800 pounds compared to 2,200 pounds of wood or 5,000 pounds of steel pole appeals to utilities servicing areas with challenging terrain.
Of course, utilities have their own suggestions for improving ease of use. McDonald, for example, says he'd like to see a wider range of adjustability on the clamps holding electrical lines on composite transmission arms. Brammer says color-coded end caps on the crossarms would help linemen more easily determine an installed products’ strength at a glance from the ground. These composite converts say that product manufacturers are quick to respond to their requests for solutions that ease the job, and they are pushing for more innovative features.

As new features are continually added, and the utilities market grows in new directions, there is every reason to expect higher levels of composite use.

Megan Headley is a freelance writer based in Fredericksburg, Va. Email comments to rmheadley3@gmail.com.

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**Make a Difference in the Market**

Consider joining ACMA’s Utilities & Communications Structures Council, one of the association’s 11 Composites Growth Initiative (CGI) committees dedicated to growing the industry. The Utilities & Communications Structures Council aims to improve power delivery and the communications infrastructure by promoting the use and understanding of composite applications. For more information or to join, contact John Busel, vice president of the Composites Growth Initiative, at 914-961-8007 or jbusel@acmanet.org.
Imagine going to a car dealership and ordering a new vehicle custom-made to your specifications, but you don’t wait a month or more for delivery. Instead, you pick up the car very next day. Thanks to advances in 3-D printed composites, that scenario is close to reality. Using technology developed by the Manufacturing Systems Research Group at Oak Ridge National Laboratory (ORNL), at least one entrepreneur is preparing to launch a car-printing micro-factory and sales outlet.

3-D printing isn’t the only recent breakthrough in composites manufacturing. Industry, universities, government agencies and others throughout the world are exploring improved methods of composite fabrication. Whether they’re working on additive manufacturing, automated production, more precise machining or new methods of molding, the goal is to make composites manufacturing faster, more efficient and cost-effective.

Bigger and Better

ORNL researchers have been working on additive manufacturing for more than 20 years, but until five years ago the projects were all small-scale. “Almost all 3-D printers are in an oven, since they have to keep parts close to the glass transition temperature for plastics. Even for metal, you have to keep the parts really hot while you’re growing them,” says Lonnie Love, corporate fellow and group leader at the Department of Energy’s Manufacturing Demonstration Facility (MDF) at ORNL. Using ovens limited project size and required a lot of energy.

Then the researchers realized that carbon fiber could solve some of the technology’s fundamental problems. “When you put in carbon fiber, it not only increases the strength and stiffness, it also increases thermal conductivity and decreases the co-efficient of thermal expansion such that you no longer need the oven,” Love says. That eliminated all size constraints.

Using carbon fiber, a gantry system and additive manufacturing, ORNL successfully partnered with Lockheed Martin to print big molds for sheet metal forming and composite tooling. “We could make something in a day for thousands of dollars that typically would take months and cost hundreds of thousands of dollars,” says Love. BAAM (Big Area Additive Manufacturing) became a game-changer.

In 2014, ORNL teamed with Cincinnati Inc., a build-to-order machine tool manufacturer, to adapt its laser cutting machine to additive manufacturing. They partnered with car manufacturer Local Motors and printed a composite car during the International Manufacturing Technology Show in September 2014. Cincinnati Inc. has since sold several of its additive printing systems to manufacturers in various industries,
and Local Motors plans to sell 3-D printed cars this year at its microfactory across the street from the Manufacturing Demonstration Facility in Knoxville, Tenn.

Over the last few years, ORNL has 3-D printed everything from a Shelby Cobra and a house and vehicle that wirelessly share energy to molds for plane parts and wind turbine blades. During this time, researchers have steadily reduced the time it takes to print these structures. To keep costs down they use readily-available injection-molding pellets as the printing material. The technology has received critical acclaim in the composites industry, winning the 2015 CAMX Combined Strength Award.

“We can now make large structures extremely fast and extremely inexpensively,” Love says. “You can make molds, jigs and fixtures, but if you want to make an end-use part, you don’t need any tooling; you can just go directly from your CAD design to the part, so everything can be different. One of the big benefits of additive manufacturing is mass customization of a product.”

The degree to which additive manufacturing will replace traditional manufacturing depends largely on two factors, says Love. The cost of the machines and materials must drop, and the reliability of the technology must rise.

Automated Production

While additive manufacturing offers exciting possibilities, research labs and private-sector companies have been improving traditional manufacturing methods as well. Automation is often at the forefront of these improvements. Car manufacturers use robots to assemble relatively small, consistently-shaped parts.
New Multifunctional Materials Drive Advances in Manufacturing

Advances in manufacturing go hand-in-hand with development of new materials. This is especially evident in the area of multifunctional composite materials, where a quick glance at potential military applications reveals the need for compatible manufacturing processes.

For war-torn areas, autonomous vehicles manufactured with protective multifunctional materials could shield both civilians and soldiers in dangerous environments. Some of the required manufacturing technology already exists. Composite materials currently used for soldiers’ personal protection (Kevlar® and Dyneema® helmets and body armor, for example) could be incorporated into Robotic Augmented Soldier Protection (RASP) to deflect hostile projectiles, such as ballistic fragments or bullets.

Robots with built-in composite fiber nets could catch and defeat autonomous vehicles launched by hostile forces, while those manufactured from “smart” composite materials could travel to wounded soldiers during a battle to provide medical treatment and better protection from ballistics. Self-assembling, lightweight composite autonomous vehicles could reconfigure themselves to build shelters or could carry ultra-light, ultra-strong tows to construct an emergency bridge.

“Other composite processes could enable multifunctional robotic platforms that could build protective barriers on site from indigenous materials such as sand or cement, deploy filters for water purification, or autonomously deploy energy harvesting devices manufactured from composite materials for small or temporary wind farms and solar collectors,” says Shawn Walsh, a researcher with the U.S. Army Research Laboratory at Aberdeen Proving Ground in Maryland.

Before such robots can become a reality, however, there’s more work to be done. “As new robotic enabled capabilities are invented and use composites, they may need new and unique manufacturing processes that don’t currently exist, or that require radical modification,” Walsh says.

But these robots don’t work with large CFRP parts because the parts lack shape consistency due to hand-laying fabrication and autoclave curing.

The Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM has been looking at ways to overcome these problems. Dirk Niermann, who heads the department of automation and production technology, says researchers, working with Airbus, used precise measuring, computer software and off-the-shelf robots to join large CFRP parts on a fuselage.

Although the geometric difference between the manufactured CFRP fuselage parts is small – under one millimeter, according to Niermann – this difference is too great when you have to drill holes in the fuselage within an accuracy of 0.1 or 0.2 mm. To ensure that the holes go in the right position in each fuselage shell, Niermann’s team measured the size, shape and position of every element in the placement process, from the shell to the robot system itself. They then input the data into a software program. With the image in the computer’s virtual world exactly reflecting reality, researchers could control the robot’s precise placement of brackets, pins and spars for the fuselage’s interior.

There were other challenges when it came to joining two sections. Although CFRP parts are stiff, they are limp when large and very thin. Manufacturers usually force the parts into rigid shaping jigs for joining, but this creates stress in the part. So the Fraunhofer IFAM researchers developed a flexible jig, a shape and positioning robot with vacuum actuators.

Using precise measurement data, the computer determined the geometry of each fuselage shape for the best fit, then directed the vacuum actuators to gently move the parts into position. This minimized stress on the parts, optimized the forces applied for joining, minimized the gap sizes and allowed more precision in the amount of adhesive used.

“We did all of this using robots off the shelf – the robots the automotive industry uses,” Niermann says. The team “taught” the robot, positioning it in 15 different ways and measuring the difference between its actual position and the ideal one. Using this data, a software program created an individual mathematical model to control the robot in a very precise way. The program even allowed for the bends in the linear track caused by the robot’s weight as it moved along the axis.

“There are other, already known ways to ‘use’ such data, but our unique way – via the adaption of the mathematical model that controls the robot – makes the decisive difference between precise enough for our purpose or not usable for our purpose,” Niermann says. “With this method, we make sure the robots ‘know’ their own deviations and act accordingly.”

Using robots and a camera system for the final quality inspection improved the speed and accuracy of manufacturing.
“We used half the time, sometimes one-third the time that the human teams needed to perform the same tasks,” Niermann says. “And this automation has high reliability, which is what the industry looks for. We don't have the variances of human work.”

The jig with actuators and the robot positioning algorithm offer manufacturers more flexible production processes. “This jig can hold every type of part, and the robot can work on every type of part,” Niermann says, noting that this is a much cheaper solution than any used today.

Precision Machining

One of BCT GmbH’s contributions to industry advancements focuses on precision machining for composite repair and manufacturing. BCT uses a six-axis, precision measuring system in applying its adaptive machining and system integration expertise to automation of composite repair.

“Our core challenge was to significantly increase the speed and precision of the scarfing process for composite components in need of repair,” says Jan Bremer, project engineer, composites. “Adaptive machining allows fully-automated machining processes on components which have individual deviations while maintaining high precision.”

For one project on a large helicopter fuselage, BCT scanned the component with a laser line scanner. It then digitized the information and adapted its usual three-axis machining path program into a five-axis program to allow for the component’s curvature. (The five-axis program can be “translated” into programs for all types of numeric control machines, Bremer says.) This process ensured that the machining tool followed the fuselage’s exact shape. “When scarfing, it is extremely important to machine to tight tolerances to avoid unwanted damage to underlying areas or components,” Bremer says.

The biggest advantages of this automated process are its increased speed, precision and traceability, he adds. Using a precise machine tool minimizes human error, while digitizing the before and after scarf allows storage of information for later documentation. The same technology can also be applied to machining of parts to ensure better fit during manufacturing.

“I see major advantages in more efficient and precise machining operations, especially when considering the possibility of running machining operations on smaller and more flexible machines that can even work in parallel on large components,” Bremer says. “This could do away with the need for extremely large machinery in many applications, greatly increasing the efficiency of today’s manufacturing processes.”

Larger-scale Production

Teijin Limited of Japan introduced its Sereebo™ carbon fiber reinforced thermoplastic (CFRTP) about five years ago and since that time has worked with GM and other partners on exploring its potential. What sets Sereebo apart from other CFRTPs, according to Teijin, is the longer length of its carbon fibers.

“We are able to control the distribution and the orientation of those fibers very well,” says Eric Haiss, vice president at Teijin.
Advanced Composites America. “So we get isotropic properties in the base material, and we can maintain those properties in the final molded parts.” With its strength and 60-second takt time (which synchronizes rate of production with rate of demand), Sereebo provides the performance required for mass production of structural parts in automobiles, adds Haiss.

“When you go into a typical thermoset process – a high pressure RTM process – that will top out at around 50,000 units a year. That’s pretty much where our process will start,” he says. “Our target is to go after hundreds of thousands of vehicles a year, maybe even millions of units.” Haiss envisions a system where the Sereebo parts would be molded in a factory located near its customers’ factories, with the material itself supplied from a centralized location.

Parts made with Sereebo are typically 20 to 30 percent lighter than those made with aluminum, but they are priced slightly higher. “There are features in our material – maybe better fatigue properties or better impact properties than aluminum – that will give us an edge in certain applications,” says Haiss.

The material is now in the final stages of production process validation trials, and Sereebo may soon move into actual vehicle applications.

**Laboratory Research**

The Institute for Advanced Composites Manufacturing Innovation (IACMI-The Composites Institute) is a recently-established U.S. consortium of industry, research and state partners working together to accelerate development and adoption of cutting-edge manufacturing technologies for low-cost, energy-efficient manufacturing of advanced polymer composites. IACMI’s mission is to help composite laboratory processes and materials make the big jump to commercial readiness. Its five research areas include vehicles, wind energy, compressed gas storage, materials and processing, and modeling and simulation. It also is collaborating with ACMA on composites recycling and workforce development.

“Within the materials and processing area, we include fibers and resins,” says Cliff Eberle, IACMI’s area director. “Our emphasis is on low-cost carbon fibers because that’s where we see the greatest need and opportunity for making dramatic changes.”

While the aerospace industry has made advances in carbon fiber manufacturing, its breakthroughs are geared to extreme performance at high cost and low volume. “What we’re trying to do at IACMI is extreme volumes at low cost and high, but not super, performance,” Eberle says.

IACMI currently has three projects underway. In wind energy, researchers are looking for ways to reduce the cost of turbines and be more cost competitive. In the compressed gas storage area, the aim is to lower the cost of onboard storage of less-polluting alternative fuels such as natural gas. Researchers in the automotive area are focusing on three processes – prepreg compression molding, high pressure RTM and hybrid molding, says Eberle.

With hybrid molding, manufacturers can take a simple prepreg, compression molded or HPRTM molded part and add complex features by over-molding in an SMC or injection molding process. “You can actually flow materials to give you the complex features but you’re getting the strength and rigidity from the continuous fiber architecture in a prepreg or RTM,” Eberle says. The five-year goal for all three processes is a three-minute,
IACMI researchers primarily use the equipment already available through its university and national laboratory partners and is strategically growing its capabilities. “In Detroit we are collocating in a full-scale facility where we will have a 4,000-ton compression press, a 3,000-odd ton injection molding press, a full-scale HPRTM unit and a half-meter prepreg line,” says Eberle. “All of this allows us to prototype full-scale automotive parts in that facility.” This investment is necessary because the consortium’s automotive members can’t interrupt their full-scale production lines to conduct research.

The new automotive composite equipment will be located in the same building as the Lightweight Metals Manufacturing Institute (LIFT), which Eberle says is exciting and makes sense. “We don’t think the car of the future will be a composite car; it will be a multi-material car that will use composites, aluminum, steel and other light metals,” he says.

With the variety of research in composites manufacturing that’s going on today, it’s too early to tell which new technologies or processes will actually succeed in the real world market – or when. But with so many viable options, future developments are sure to open up new and exciting possibilities for using composites.

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

The body of the 4-passenger Sereebo™ concept car was formed in just one minute and weighs approximately 103 pounds – a fifth of a comparable steel structure.
Composites

Manufacturing

By Patrice Aylward

Composite sandwich structures utilizing core materials such as honeycomb, aluminum, balsa wood and foam have a lot to offer product manufacturers, including high strength and stiffness-to-weight ratios, good fatigue behavior, decent surface quality, effective noise dampening and fire/smoke/toxicity protection. Bonded sandwich structures have been a basic industry component for decades in a range of end markets where structural requirements are high, such as aerospace, transportation, marine and wind energy.

But three-dimensional shapes and high-volume production pose challenges for cores. Sometimes structural cores are too expensive or don’t meet the required manufacturing criteria, including reduced cycle times or an economically favorable price point. Where there is a market, however, there is research and development. Core suppliers have upped their offerings. Providers of sandwich structure cores are finding answers for many challenges, including:

• Volume demand
• Reduced part weight
• Lower costs
• Stricter fire standards
• Environmentally-friendly materials and production methods
• More efficient production methods, especially for high-volume production

Here are some of the developments from several core material suppliers tackling these challenges.

Advances to Enable Mass Auto Production

As with all material segments of the composites industry, innovations in core materials are driven by demand from automotive companies. Evonik, a global specialty chemicals company, has its eye on the mass production of structural components in complex shapes for the automotive industry. ROHACELL® Triple F, a polymethacrylimide (PMI) rigid foam core, has been under development for about five years. It aims to make complex three-dimensional core shapes a possibility, while at the same time enabling large-scale production of the high-performance foam cores through a proprietary in-mold foaming (IMF) process. Evonik believes the process is capable of producing up to 50,000 complex 3-D sandwich structures per year.
The Evonik research and development team devised the new IMF process for PMI rigid particles to reduce costs per part through the reduction of waste, manual work and cycle times, especially since multi-cavity tools for IMF are able to produce two or three cores at a time. “It depends on the part, but we have been able to obtain the desired foam core shape two to three times faster than with CNC milling,” says Dr. Kay Bernhard, head of research and development for performance foams at Evonik.

The proprietary process calls for PMI polymer plates to be pelletized and then pre-foamed to a desired density. At the end of this phase, there is still enough blowing agent within the polymer particles to repeat the foam formulation in the next stage, within a closed mold. When heating the mold to temperatures between 356 and 482 F (180 – 250 C), foam formation begins again and the granules expand. The particles deform and fill the interspaces within the mold as they face the limited volume of the mold cavity. Cooling brings the polymer back into a solid state. The 3-D foam cores are ready to use in efficient curing processes, such as high pressure resin transfer molding or wet impregnation.

Thermal properties of ROHACELL Triple F are comparable to block material, but the particle foam cores have lower compressive strength and shear strength compared to Evonik’s traditional sheet foam core due to the low adhesive forces acting on the particle boundaries. To improve the performance of the foam cores, an adhesive agent is added to the pre-foamed granules. High temperatures used during IMF melt the adhesive agent, providing good particle-to-particle adhesion after cooling. This improves the mechanical performance of the foam core, especially at high densities, according to Bernhard. And with no open pores, there is less resin uptake, which contributes to lower part weight.

The complexity of the foam core shape is limited only by the designer’s imagination, says Bernhard. Integrating metal and plastic inserts with high-temperature resistance during molding provides another short cut, enabling the production of integrated structural components such as a core with screw threads already embedded into the core.

ROHACELL Triple F foam cores will likely be combined with CFRP for automotive structural components such as car bodies, chassis and add-on parts. To date, Evonik has tested the IMF processing of PMI cores in partnership with two German automotive manufacturers to produce structural parts such as pillars and struts. Applications in sports equipment, aviation and other markets are also of interest.

Options for High-Volume Production

3A Composites is adding to its capacity with the installation of a new extruder in its Glasgow, Ky., plant, showing great faith in the company’s AIREX® brand polyethylene terephthalate (PET) foams and its latest product introduction, AIREX T10, a closed-cell, recyclable foam available in a 39.5 x 96-inch format (1005 mm x 2440 mm) with a flexible thickness range of 0.20 inches to 1.77 inches (5 mm to 45 mm). Russ Elkin, product development manager, USA for 3A Composites, describes AIREX T10 as the “industrialized” structural foam core intended for high-volume sandwich applications.

“AIREX T10 is designed for parts subjected to static and dynamic loads and/or exposed to elevated temperatures during processing,” says Elkin. “The product’s homogenous cell structure has improved mechanical properties at equal density compared to previous generations of welded PET foams.”

A streamlined extrusion process eliminates welding lines and minimizes the downstream operations to produce the sheet. The new direct extrusion process allows for consistent material properties and greater quality control, features that are critical in large-volume manufacturing. In addition, eliminating several steps saves money, and a favorable price/performance ratio is critical in mass-production environments.

In a recent study of core materials for 80-meter wind turbine blades conducted by the design management and technology consultancy STRUCTEAM, AIREX T10 PET foam core significantly reduced the cost of the blade over PVC and standard welded foam core. In addition, the total weight of the PET-based T10 solution was on par with PVC-cored sandwich.

Opportunities in Aerospace

The automotive and energy markets aren’t the only ones seeking new core solutions. Solvay Specialty Polymers has made several moves calculated to improve its position as a supplier of foam cores and composite sandwich structures to aerospace manufacturers, particularly given the industry’s backlog of commercial aircraft.

In 2015, Solvay unveiled its TegraCore® R-1050 polyphenylsulfone (PPSU) foam core. “Outdated supply chains developed for much lower aircraft build rates are a bottleneck to manufacturing more airplanes quicker,” says Armin Klesing, global business development manager for Solvay Specialty Polymers’ aerospace and composites business. Solvay’s TegraLite® sandwich structures are designed to expand options for multifunctional parts and part commonality, which can help budget carriers control costs. “For premium carriers, the technology offers new solutions for greater differentiation and enhanced customer experience in the cabin while maintaining control over part weight,” says Klesing. “Another feature is the ability for on-board repair instead of needing to remove parts from the cabin.”

TegraCore R-1050 PPSU foam core is designed to prevent uncontrolled crack propagation upon impact and withstand prolonged exposure to water, chemicals and temperatures ranging from -40 to 400 F (-40 to 204 C). TegraCore is manufactured using a proprietary continuous extrusion technology that yields a controlled and narrow distribution of isotropic closed cells. The process is capable of producing foams in the range of 2.8 lb./ft³ to 7.5 lb./ft³ (45 kg/m³ to 200 kg/m³).

“There are foams that exhibit good mechanical properties but perform weakly in heat release and smoke production in the case of fire, or exhibit brittle failure,” notes Klesing. “Others exhibit good flammability properties but are friable and limited in chemical resistance. TegraCore is a universally specifiable high-end core solution.”

TegraCore PPSU foam is now an Airbus-qualified core product used in several undisclosed applications in the cabin of the Airbus A350. The floor panel of the Solar Impulse 2 solar-powered aircraft also was made out of TegraCore PPSU foam. Klesing indicates the foam is available globally in large quantities for a range of heavy-duty applications that require low weight and insulative performance combined with high resistance to damage, fire and exposure to chemicals.
Solvay’s July 2015 acquisition of Cytec Industries Inc., a U.S. company with a formidable presence in aerospace composites, was well-timed with the introduction of TegraCore R-1050. The acquisition of Cytec implies that TegraCore will soon be offered in a broad range of sandwiches with epoxy, phenolic, PEKK and sulfone-based composite skins.

Solvay will continue partnering with other suppliers of foam core technologies, such as 3A Composites, for aeronautics lightweighting. “3A Composites can apply its expertise in industrial process development and high-volume fabrication of foams to Solvay’s polymer technologies,” says Klesing. “We are joining forces to offer innovative specialty foam materials on a large and worldwide scale as a cost-effective substitute to traditional, labor-intense materials used to reduce the weight of applications.” The alliance should help Solvay with global logistics and regional support.

Innovative Honeycomb for 3-D Parts

Euro-Composites Corporation has taken the flexibility of honeycomb cores for sandwich structures a step further with the introduction of ECA-3D, an aramid fiber honeycomb core formable in multi-directional curvatures to create complex shapes without the need for heat forming. The new honeycomb core is applicable to any situation where acute or compound curvature is required.

The company is targeting aerospace interiors as well as wings, stabilizers, radomes and more with ECA-3D. “It’s so new, we’re just in the process of gaining market feedback,” says Barry Millward, vice president of sales and business development. “We’ve had interest from major commercial aircraft and helicopter manufacturers, as well as manufacturers of unmanned aerial vehicles.”

ECA-3D features durable, teardrop-shaped cells that impart flexibility to the core equal to multi-directional curvature without collapsing the cells or compromising shear strength, says Millward. Introduced in 2015, the ECA-3D core was developed at Euro-Composites’ Center of Excellence in Luxembourg. Cell size is currently equivalent to a traditional 3/16 cell and with a density of 3.0 pcf. Sheets are available up to 48 x 96 inches and 36 inches thick. Millward indicates that higher densities are under evaluation.

Structural cores in complex 3-D shapes can be embedded with integrated inserts, such as screw threads shown in this test mold, using Evonik’s ROHACELL® Triple F rigid foam core.

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The aerospace grade honeycomb is constructed of aramid fiber paper, such as DuPont Nomex®, and coated with heat-resistant phenolic resin for resiliency and low density. Nomex honeycomb is preferred for aviation applications because of its fire resistance and low moisture retention.

For the end user of ECA-3D, manufacturing costs may be reduced since the core eliminates the need for heat forming prior to use as required by hexagonal core. “You just lay it out and use it. This dramatically reduces the manufacturing costs and time to produce a sandwich structure,” says Millward.

**Paper Honeycombs Continue to Thrive**

There are simple, traditional core technologies that continue to get the job done for sandwich structures. Paper honeycomb has been used in FRP products since the early 1960s, says Steve Loudin, owner and president of Tricel Corporation, a manufacturer of paper honeycomb. “It’s an economical, efficient honeycomb core that is easy to bond with."

In fact, paper honeycomb is a popular product for cores in automotive sandwich structures and is giving Loudin’s business a big boost. “Our sine wave honeycomb core is now being used in about 30 different car models,” says Loudin. Component parts incorporating Tricel’s honeycomb core include package trays between the back seat and back window, load floors in the trunk storage area and sun roofs. One Tricel customer manufactures 50 small GFRP buses a week for car rental companies. The roofs and side walls of these transport vehicles incorporate a Tricel honeycomb core and FRP sandwich structure. “Lightweighting is the future of the automotive industry, and our honeycomb core is a part of it,” says Loudin.

Covestro (formerly Bayer Materials Science), the supplier of Baypreg® two-component polyurethane resin systems, partnered with Tricel to develop a sandwich structure that was first trialed in Europe. While the European project utilized a small-cell, thin honeycomb, the U.S. team adapted the process to Tricel’s ¼-inch cell honeycomb core. The compression strength is about 34 psi, with a cell size of ¼-inch and a density of about 2.66 lb./ft³.

At CAMX 2015, Covestro presented the results of the partnership with G&G Industries, a Tier 2 supplier to the automotive industry. An automotive interior load floor and sunshade were manufactured using Tricel honeycomb core, Baypreg polyurethane spray and fiberglass mat to compression mold a laminate in an environmentally-friendly, low-emission process. The components are based on a lightweight sandwich that combines flexural strength, torsional stiffness and sound-absorbing properties.

There’s no question that aerospace, automotive and energy are the top three markets driving the development of new technology for structural cores. However, Elkin says other markets, such as construction and sporting goods, are also changing how and where core materials are being used. “With the right application,” he says, “structural cores help make an end product with better quality, lower weight and high productivity.”

Patrice Aylward is a communications consultant based in Cleveland. Email comments to paylward@aol.com.
It’s Membership Renewal Season!

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CMA membership renewal season starts April 1. Don’t forget to budget for ACMA membership dues and programs. If you’re not already a member, join today! To learn more about the benefits of ACMA membership, contact Paul Hirsh at phirsh@acmanet.org.

ACMA Hosts Infrastructure Day

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uring ACMA’s annual Infrastructure Day in February, association members took to Capitol Hill to inform members of Congress and federal agency leadership about the value of composite materials in American infrastructure. ACMA members advocated for the use of composites in bridges and other key infrastructure markets, such as utility poles and crossarms, water and wastewater treatment, locks and levees, and pipes and tanks. For all sectors of the composites industry, this was a critical opportunity to directly influence leaders in Washington, D.C., and build relationships with members of Congress. For more information on how you can engage with leaders in Washington, contact MJ Carrabba at mcarrabba@acmanet.org.

New Standard for FRP Crossarms

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here is now an ASTM test method designed for composites in crossarms. The standard, ASTM D8019-15, is available online for $44 at astm.org/Standards/D8019.htm. This is important, as previous test methods were designed primarily for wood. Now manufacturers of FRP can compete with wood in this critical market. The creation of the standard was made possible by ACMA’s Utility & Communications Structures Council (UCSC) and its chair, Creative Pultrusions’ Dustin Troutman. For more information, contact John Busel at jbusel@acmanet.org.

Composites Executive Forum – April 5-6, 2016

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ave the date for this year’s Composites Executive Forum in Washington, D.C. The forum is designed for industry leaders and covers topics of specific interest to them. Offered every two years, this is an unparalleled chance to network and learn with industry leaders. This year’s topics include macro and micro trends in markets; the economy and politics; finding, hiring and developing the right people; managing relationships with supply chain partners and customers; and business development and evaluating new business opportunities. Find out more and register at acmanet.org/cef.
AIA Composites Pavilion Spaces Going Fast

ACMA is hosting the Composites Pavilion for a third year at the American Institute of Architects (AIA) show. This year’s show is in Philadelphia from May 19-21. The pavilion consists of 30 booth spaces, which are available exclusively to ACMA members. The pavilion is at the front of the hall between the two main entrances, which makes it an unparalleled location to leverage your communications and marketing to over 18,000 architects and potential clients. New this year is Composites Central – a 400-square-foot educational presentation and networking area where pavilion participants may give a 15-minute educational presentation in one of the highest traffic areas in the exhibit hall. For more information, contact John Busel at jbusel@acmanet.org.

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For more information on becoming a member of ACMA, email membership@acmanet.org or call 703-525-0511.
When Graham Mulholland got a call from U.K. television producers asking him to build the world’s fastest sled for a show starring speed aficionado Guy Martin, he knew his company would be up against a time crunch in more ways than one. In order to make the world’s fastest sled, Mulholland would need a frame that was both aerodynamic and strong. However, the sled itself wasn’t the only thing that would need to be quick.

“You’re never far away from time when dealing with TV schedules, and we had to make [the sled in] time before the venue was in season,” says Mulholland, managing director at EPM Technology, a Derby, U.K., company specializing in composites manufacturing for aerospace, defense and motorsport applications. “Therefore, making the component lightweight and yet structurally sound was a big challenge, as it really had to be right the first time.”

One way the team saved time was by cutting direct tooling into composite blocks. Despite size challenges and design complexities, EPM was able to produce the main body as a single piece. EPM used a prepreg CFRP to mold the structure that was then cured in an autoclave.

“Prepreg carbon gave us a low-cost process which could enable EPM’s engineers to specifically dial in the structures to optimize the sled,” says Mulholland.

Martin’s speed attempt featured a 984-foot run with 360-foot drop, which was at times steeper than the main climbing route on Mt. Everest. In January 2014, thanks to the design and structure of the sled, Martin beat the existing sled speed record by nearly 20 mph, reaching 83.5 mph on the Pyrenees slopes in Andorra.
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SALES CONTACTS

Eastern U.S. & International
Sean Nodland
703.682.1673
snodland@acmanet.org

Western U.S. & International
Efren Pavon
626.331.0616, x616
efren@sampe.org

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