Composites
Key to Vertical Gardens

University Report:
6 R&D Projects

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By Mary Beck
Greetings to all of my regular readers as well as those of you who are attending CAMX right now. For those of you reading this before the big show, I hope you have registered. CAMX has indeed exceeded all of our planning predictions. Check out theCAMX.org for details and to sign up.

Hats off to the CAMX Steering Committee for all its hard work putting together an event that is really worthy of your attendance. The committee is made up of volunteers (one of my favorite words) and staff from both SAMPE and ACMA. It has been a huge challenge to develop a show of this magnitude from scratch, but it is a challenge that has been embraced from the very beginning. New education, networking and other events have been incorporated into the show, as well as many of the things that you have always enjoyed at either SAMPE’s Annual Spring Convention or ACMA’s COMPOSITES. Through our joint efforts, CAMX is definitely bigger and better.

If you are reading this column at CAMX, then I offer you a warm welcome. You will undoubtedly learn more about composites and meet real industry experts. On behalf of the Steering Committee, I thank you for coming to Orlando. And while you are here, I encourage you to become a member of ACMA if you are not already. Visit the ACMA booth (4478) on the show floor for membership information.

One of the key offerings at CAMX is the educational sessions for all of our attendees. Whether you are interested in the Certified Composites Technician programming or theoretical research discussions, you can find them here. This issue of Composites Manufacturing also touches on some innovative university research. (See the article on page 14.) There is always a correlation between work being done in the academic world and the production of composite parts.

Now a few words about our association. With the success of CAMX, ACMA is stronger than ever. The scope and quality of member benefits has never been better. An example is the recent American Institute of Architects Convention in Chicago, where a group of ACMA members joined forces for a first-ever Composites Pavilion. It was a huge success! That effort was by members and for members, with some help from ACMA staff. It will be even bigger next year. The value of membership is a bargain, and the more you participate, the more value you get back.

I hope to see you in Orlando. I will be around the exhibit hall all week, so be sure to introduce yourself.

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You Don’t Need a Better Sales Process

With more than half of the year behind us, so many companies are looking to improve the sales performance of their teams. Their usual self-diagnosis? “We need a better sales process.” This is usually followed by a request for a program to reshape their sales process, in hopes that it will help them rise above the economic pressures and rapid commoditization in the market.

This isn’t the best solution. In fact, a 2012 study from the McKinsey Center for Business Technology revealed that 75 percent of the efforts at companies using one of the hottest sales process methodologies in the field – solution selling – were deemed failures within three years. That’s because it’s not about the sales process: It’s about having the right message, one that clearly explains to customers why you’re the best choice for them. The right message will help your company stand out, no matter how many other companies are operating in your niche – and even if you’re not the lowest-priced option.

So many companies find themselves in such a competitive environment – and an incredibly commoditized one. Your customers are inundated with incredible amounts of information and data from you and your competitors. They’re forced to make very complex buying decisions, and many of them are overwhelmed by the process. To complicate matters, the messaging that most companies are offering isn’t resonating, compelling or useful. It’s just noise, and it isn’t cutting through all the clutter.

As a result, you and your competitors all look the same. You all sound the same. Therefore, your customers believe that you are the same.

By definition that makes you a commodity, and that’s a tough position to be in. You’re at the mercy of the market and your

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To create sales messaging that helps your team close more deals faster, it has to accomplish all three of these. Otherwise, your proposal will likely end up buried in a pile of other similar proposals that never see further action.

If you're experiencing a tough selling environment this year, there is an answer — and it lies in your sales messaging. With the power of messages that set you apart from your competition and show your customers why they need your solution and need it now, you can make the rest of 2014 a roaring success.

Kevin McArdle is the founder of McArdle Business Advisors. For additional Best Practices resources and articles on moving your business forward, visit McArdleBusinessAdvisors.com.
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Even before visitors to the Pérez Art Museum Miami walk through its doors to admire more than 1,800 pieces of modern and contemporary art, they are treated to an artistic masterpiece. The 200,000-square-foot museum, opened in downtown Miami in December 2013, features hanging gardens all around the building. JTI Companies Inc. in Birmingham, Ala., fabricated a superstructure comprising seven chambers with 67 FRP tubes that descend from a canopy and hold 80 different plant species native to Florida. The lush, green flowering vertical gardens are breathtaking.

JTI was brought into the museum project by the architect of record, Handel Architects, whose primary concern was that the gardens could withstand hurricane winds. “When they approached us, they had a conceptual drawing with some lines coming down in a vertical garden, but they did not have any specific technology in place,” says Jason Brough, president of JTI. “They were considering alloys and other materials that were cost-prohibitive. But the driving factors were selecting a material that could stand up to 146 mph winds and resist saltwater corrosion.”

Founded in 1990, JTI’s commercial division focuses on large architectural projects. One of the reasons clients choose the company is because it offers both composites fabrication and metalworking. “That combination allows us to do the ‘hard-to-dos’ – the projects that are unique and people think can’t be done,” says Brough. Projects like the hanging gardens.

“This was a one-of-a-kind project that had to go off without a hitch for the general public. There was no second chance. And there was no benchmark.”

Jason Brough, President
JTI Companies Inc.
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As the delegated engineer for the museum project, JTI designed and fabricated a complete structural support system for all seven chambers of the vertical gardens. Each chamber features eight to 11 custom FRP tubes. “It looks like a set of wind chimes,” says Brough. “The only difference is these tubes are 18 inches in diameter and anywhere from 28 ½ to 51 feet long.” JTI devised a laminate structure that would bend, but not break, under hurricane strength winds. The tubes are constructed of matte woven roving and C-veil fiberglass, Hardwire® high-strength twisted steel wires and K022-AA epoxy vinyl ester resin from AOC.

Walter Brough, P.Eng., project manager for JTI, oversaw the design and testing phase. AOC provided several resin samples, which JTI sent to a testing lab to obtain the physical properties of the combination of fiberglass, Hardwire and resin. Using that information, Brough and his team conducted a computerized stress analysis to determine the necessary tube thickness and what layers were required to limit deflection. JTI selected the K022-AA resin because it is fire-resistant (critical in an architectural application) and corrosion-resistant (important in the museum’s coastal environment). Inclusion of the Hardwire steel wires increases the strength-to-weight ratio of the tubes while maintaining flexibility: The tip of each tube will move a maximum of only eight inches in 146 mph winds.

The team at JTI fabricated the tubes using hand lay-up, alternating layers of fiberglass and Hardwire in a sandwich construction to create the 3/8-inch thick tubes. JTI built custom 40-foot-long mandrels to accommodate the project. Even then, technicians had to slide the tubes out of the mandrels and continue making the ends of the longest tubes on specially created extensions.

One of the biggest production challenges was dealing with varied weather conditions. “This project spanned several months,” says Jason Brough. “In our Alabama plant, we would find ourselves dealing with drastic temperature changes from one day to the next.” AOC worked closely with JTI to help the company promote the resins based on environmental conditions and stay on the tight production schedule.

Once completed, JTI shipped the components of the inverted garden to Miami along with installation instructions written by Walter Brough. Installation took six months. Each of the seven chambers comprise tubes, tension rods and compression struts, which are attached to the walls and structural steel at the top of the building. The tubes, which descend from those chambers, are covered with felt that has pockets cut into it. The plants are placed in those pockets, and water is delivered into the felt through nozzles at the top of the tubes. The water works its way down the tubes, sustaining the plant roots in a soil-less system. The museum's inverted gardens were designed by French botanist and inventor of the vertical garden, Patrick Blanc, who received technical implementation assistance from ArquitectonicaGEO, a landscape architecture firm.

“This was a one-of-a-kind project that had to go off without a hitch for the general public,” says Jason Brough. “There was no second chance. And there was no benchmark.”

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

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Driving around in a 3-D printed car is all in a day’s work for Local Motors CEO Jay Peters. “I’m driving it every day,” Peters says of the vehicle, a prototype for the soon-to-be-built Strati. The Strati will be constructed on the show floor of the International Manufacturing Technology Show (IMTS) in Chicago this September using 3-D printing technology — also known as additive manufacturing or direct digital manufacturing (DDM). The technology facilitates fabrication of components from computer design to the actual part.

Approximately 90 percent of the two-person, electric Strati will be made from composites, with a single carbon fiber reinforced thermoplastic part that integrates the chassis, body and interior. Once the engine, lights and other components are added, the Strati will have a mere 20 parts — a marked contrast to traditionally manufactured cars, which can have up to 25,000 parts, says Peters. “It’s about simplicity,” explains Peters, who founded Local Motors in 2007 to “decomplexify” auto manufacturing and speed up innovation.

To that end, Local Motors’ products, which range from electric skateboards to motorcycles and off-road vehicles, are produced in small lots in micro-factories or “cells” that also sell and service vehicles. Peter says these “rapid products” can be changed very quickly, even unit by unit — a far cry from the weeks- to months-long shut downs that can occur to retool and retrain for year-end model changes in traditional manufacturing. Local Motors’ products also are co-created or crowdsourced — designed, developed and vetted through a community of professional and hobbyist contributors. The Strati’s design was created by automotive designer Michele Anoé of Italy, who won a contest held by Local Motors last spring.

The 3-D car project began several years ago as a quest to produce a car with a greatly reduced part count. Local Motors was already using additive manufacturing to construct its Rally Fighter off-road vehicle. The Rally Fighter, like other vehicles using DDM, is constructed from multiple 3-D printed panels that are affixed to a metal frame — in this case an extruded tubular steel frame — with fasteners and adhesives. Foam also is added to reduce noise. But Peters wanted to go further and print a vehicle with one cohesive chassis, body and interior.

“People would say things like, ‘Isn’t it much easier to stamp a body panel, then weld it together with something else instead of trying to make a machine that can make it all?’” recalls Peters. “But I was inspired by additive manufacturing, so we started to search far and wide for technologies and processes and machines that could allow us to [print one part].”

The search ended 18 months ago at the U.S. Department of Energy’s Oak Ridge National Laboratory’s (ORNL) Manufacturing Demonstration Facility in Oak Ridge, Tenn., where Peters and his team found a large-scale additive manufacturing system. “They were...
printing out large parts and then going back making them more accurate by milling them, and they were doing it so very quickly – way, way faster than your standard 3-D printer,” says Peters. This past winter, Local Motors signed a cooperative research and development agreement with ORNL to advance the technology and make cars.

The Strati will be 3-D printed from acrylonitrile butadiene styrene (ABS) thermoplastic that is reinforced with polyacrylonitrile (PAN) precursor chopped strand carbon fiber. Sabic will supply the carbon fiber in pellets, which can be fed into a plastic welder’s hopper. Once in the hopper, a screw forces the pellets down into a sleeve that heats them to approximately 210 degrees Celsius. The liquid reinforced plastic is then extruded out through a .30-inch diameter nozzle. Guided by CAD drawings that have been run through a slicing algorithm, the nozzle moves along an overhead carriage to lay down .16-inch layers of material. The layers cool within a few seconds and another layer can be put down. A heated build table keeps the layers just warm enough to adhere to each other.

Once completed, the part will be milled inside and out using a Thermwood five-access router that can operate on the x, y and z planes and rotate in two directions. The remaining parts will then be attached, including a 48-volt Renault powertrain, battery, motor and battery controllers, taillights with integrated turn signals, headlights, steering wheel apparatus, wheels and an electrical wire harness. Steel fasteners will be used to affix the motor and battery.

The additive manufacturing system, which Local Motors and ORNL developed from the model already on site at the lab, is being built by Cincinnati Inc. It is a gantry-style printer that can print objects as large as 12 feet long, 6.5 feet wide and 3 feet high.

Local Motors printed the prototype vehicle at ORNL in June. Because the test printer was smaller than the one that will used to build the Strati at IMTS, the prototype was printed in multiple parts that were fastened to an aluminum sub frame. It took 30 hours to print, while the company projects the Strati will require 60 to 80 hours. Peters says the company will likely start printing the Strati a day or so before IMTS so that it will be finished halfway through the show.

Once completed, the Strati will operate within an 80 to 100-mile range at speeds of up to 40 mph. The first customer will be the Association for Manufacturing Technology, which signed a contract for the vehicle built at IMTS. Other potential customers may have to wait a little longer: Local Motors has no plans to offer the Strati to the public immediately following the show.

The Strati is a technological leap for additive manufacturing, advancing car production from multiple parts with a metal frame to a single 3-D printed composite main body. CFRP adds rigidity and strength to the ABS plastic and combats thermal contractions, says James Earle, an advanced materials engineer with Local Motors. He adds, “This simply couldn’t be done without composites.”

Melissa Haley O’Leary is a freelance writer based in Cleveland. Email comments to mxh144@case.edu.
Ideas spawned in university research facilities today could become tomorrow’s industry solutions.
Advancing the composites industry hinges on fostering ground-breaking ideas. While many companies have dedicated research and development facilities, universities cater to innovation: The brightest students and professors from across disciplines team up in state-of-the-art labs and dedicate their careers to problem-solving and invention. University research teams around the world are pushing the boundaries of what we know about composites and how we can use them to improve our lives. Composites Manufacturing has highlighted six projects conducted in three countries that could greatly impact end-user markets and composite materials. Some projects are in the early stages, while others have already earned regional and national recognition. These stories are a testament to the rapid growth and future of the composites industry.

Bio-blades Rooted in Research
Project: Biocomposite wind turbine blades
School: University of Stuttgart
Location: Stuttgart, Germany
Principal Investigators: Jan Anger and Martin Hofsaess

The natural fiber composites market is expected to grow at a compound annual growth rate of 11.2 percent by 2019, according to the Global Natural Fiber Composites Market 2014-2019 report published in June. A team of researchers from the University of Stuttgart in Germany are sure to contribute to this rise. The team, comprising students from the university's Stuttgart Wind Energy (SWE) at the Institute of Aircraft Design, set out to manufacture natural fiber reinforced wind blades for a 1kW turbine in 2012. "We wanted to try new, more sustainable materials and see if it was possible to achieve the needed strength and stiffness for small turbine blades," says Jan Anger, Dipl.-Ing., a research assistant at the university.

Anger became intrigued by natural fibers several years ago during a surfing vacation to the Cornish coast of England. While there he visited the Eden Project in Cornwall. It features two large enclosures with connected domes housing thousands of plant species as well as bio-based applications. A surfboard made of natural fibers caught Anger's attention and planted the seed later germinated by the SWE: Why not use natural fibers for wind blades?

To make the project a reality, Anger and fellow research assistant Martin Hofsaess, Dipl.-Ing., contacted Composites Evolution about testing and using the company's bio-based fiber reinforcements. The SWE research team tested various fibers with different resins to validate their performance characteristics. They ultimately selected Composites Evolution's Biotex Flax high-performance reinforcement yarns and fabrics, which are based on natural flax fiber.

The main shell of each blade was constructed using Biotex Flax 2X2 Twill fabric (400 grams per square meter) to build the form and resist torque. Unidirectional 275 gsm yarn was selected for the belt and root to resist bending and centripetal forces. Students also added flax plain weave to the outer layer to resist small impacts and provide good surface quality and flax hopsack weave to strengthen the root of the blade and resist bending forces and torque.

The 1.25-meter-long blades were built in two halves using a wet lay-up process and partial vacuum infusion. The halves were then hand laminated and joined using Momentive’s RIM 135 and 285 epoxy resins. Anger says these resins were chosen because they fully cure without being tempered, are certified for wind blades in Germany and are commonly used at the university's Institute for Aircraft Design.

The team conducted several tests on material strips and later actual blades, including Eigen frequency (resonance frequency), bending, tensile and pressure tests. "In comparison to standard serial blades, the natural blades are a bit heavier and a bit softer against bending forces," says Anger. Still, researchers validated that wind blades for small turbines can indeed be built using natural fiber fabrics.

The natural fiber wind blades replaced traditional FRP ones on a rooftop turbine on campus last fall. The University of Stuttgart is currently preparing the turbine and measurement system for long-term blade testing and power curve testing. To date, there is no commercial interest, but that doesn’t deter the researchers. "After all, this is a student project,” says Anger. “It will grow with the students and their successors.”
Flakes Key to Flexible Fiber

**Project:** Carbon fiber with graphene oxide flakes  
**School:** Rice University  
**Location:** Houston  
**Principal Investigator:** Changsheng Xiang

In 2008, researchers at the Smalley Institute for Nanoscale Science and Technology at Rice University began work on a new recipe for creating carbon fiber. The goal was to develop a raw material to make carbon fiber that combines the advantages of the two primary carbon fiber precursors currently on the market – polyacrylonitrile (PAN) and mesophase pitch. The research team includes students under the tutelage of two professors: Matteo Pasquali, whose primary appointment is in chemical and biomolecular engineering, and James M. Tour, whose main appointment is in the chemistry department.

“The ideal precursor for high-performance carbon fibers should first be able to form a liquid crystal phase to produce fibers with good intrinsic alignment – a key to high performance,” says Changsheng “Charles” Xiang, a graduate student in chemistry. “In addition, the size of the precursor is important.” Because carbon fiber fractures at flake boundaries and interfaces, larger disks or longer rods would reduce the number of boundaries and therefore improve mechanical properties.

Using the raw materials PAN and mesophase pitch has limitations. While PAN-based carbon fibers have high tensile strength, they have lower stiffness due to poor alignment. Conversely, mesophase pitch-based carbon fibers offer high stiffness, but lower tensile strength because of the small flake size of individual molecules. The researchers at Rice discovered graphene oxide satisfies both requirements. “We can make the next-generation carbon fibers from graphene oxide with both high tensile strength and high stiffness,” says Xiang.

That’s good news for manufacturers in the aerospace and automotive industries, though the project is in the early stages. Still, Xiang expects a graphene oxide-based carbon fiber could become a reality within five years if a materials supplier performs enough optimization research.

The robust carbon fiber is made possible thanks to the unique properties of graphene oxide flakes created in a process patented by Rice several years ago. The flakes that are chemically extracted from graphite seem small: Their average diameter of 22 microns is approximately one-quarter the width of a human hair. But that’s huge compared with current carbon fiber precursors. For example, mesophase pitch disks are two nanometers, making graphene oxide flakes 10,000 times larger, says Xiang.

Researchers use a wet spinning process to create the carbon fiber. First, they disperse graphene oxide in water at a high concentration to form a gel solution. After mixing the solution in a high-shear rotating apparatus, Xiang and his peers use an optical microscope to examine the dispersion and the liquid crystal phase formation. “We have to make sure no aggregates exist within the gel solution, which is very important for having a continuous fiber spinning process,” says Xiang. “If any aggregates exist, the gel has to go through a filter to eliminate them. We also make sure that liquid crystal phase was formed in order to spin fibers with good alignment.”

Next, the researchers transfer the gel to the spinning instrument and apply controlled pressure to the piston to push the gel out through a small orifice. Immediately afterward, the fibers go through a coagulation bath (ethyl acetate) to wash away the solvent within the fiber. Then the coagulated fibers are collected by a rotating drum and air dried for 24 hours. The result is an extremely flexible carbon fiber. “The amazing thing about graphene oxide fiber is that it doesn’t degrade when knotted,” says Xiang. “This has never been seen with other carbon fiber or polymer fibers.” He notes that the tensile strength of commercial carbon fiber degrades 95 percent when knotted. Rice’s graphene oxide-based carbon fiber could prove advantageous for applications that require the fiber to bend or knot.

Xiang says that optimization work on the graphene oxide dispersion, spinning, coagulation and post-heating treatment still needs to be performed. But he’s optimistic. “The results are promising,” he says. “This serves as a proof of concept.” At least one industry supplier agrees: AZ Electronic Materials, a division of Merck, has licensed Rice’s process for making graphene oxide and is now scaling it to the ton scale.

GFRP Wraps Repair Bridge

**Project:** East Fork Bridge rehabilitation project  
**School:** West Virginia University  
**Location:** East Lynn, W.Va.  
**Project Director:** Hota GangaRao

After months of dividing two-way traffic between one lane that only allowed speeds of 10 mph, the East Fork Bridge of East Lynn, W.Va., finally received the repairs it needed to fully reopen in March 2014.

In 2011, the American Society of Civil Engineers declared the bridge to be one of the 13.4 percent of West Virginia bridges deemed “structurally deficient,” as section loss for the bridge’s steel H-piles was up nearly 50 percent. Funded by the U.S. Army Corps of Engineers (USACE), the National Science Foundation and the U.S. Department of Transportation, USACE structural engineers and professors and graduate students from West Virginia University’s Constructed Facilities Center (CFC) investigated various materials to determine the best solution for the deterioration problem. The team found a fast, inexpensive solution in composites.

Hota GangaRao, director of the CFC, says the team wanted a material that was “light weight, easy to handle, cost-effective, durable and noncorrosive.” The team knew from the start
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The East Fork Bridge’s piles, pictured here after rehabilitation, had corroded by more than 50 percent.

that composites would be an ideal solution and chose GFRP composite shells instead of their other option, steel jacketing. GangaRao says the GFRP materials were inexpensive compared to conventional repair costs, extremely durable, easy to install and had an aesthetically pleasing finish.

To make the repairs, the CFC used GFRP composite shells of two semi-circle shapes with a tongue-groove joint to encase the corroded steel columns. First, the team power washed the steel columns to remove rust. Next, they removed two feet of dirt and debris below the mud line to establish noncorrosive portions of steel bents and encased the composite shells there. They sealed the bottom of the shells with special epoxy concrete to block the water coming up from pressure and capillary action and pumped in self-consolidated concrete. Finally, they wrapped the outer part of shells with GFRP wraps and finished by painting the wrap.

The team finished the repairs in three weeks in March, and the rehabilitation was fully completed in May. The repairs brought the bridge back to its original design capacity at just a fourth of the price of conventional construction costs and are expected to last for the rest of the bridge’s lifetime, according to reports from the CFC.

This project proved to be unique for both the USACE and GangaRao. Until now, the USACE had never used such composite materials to repair aging civil works infrastructure. GangaRao, also a professor of civil and environmental engineering at WVU, says he has conducted bridge beam rehab and viaduct rehab projects, but never a bridge pile repair.

The new ventures paid off; in June, the USACE announced that the team received the 2014 Engineering Excellence Award for the Great Lakes and Ohio River Division. The award recognizes excellence in sustainability, design, construction and innovation throughout the division’s area of operations, which includes 17 states.

“It really was a group effort among the engineers and tradesmen throughout USACE, professors and graduate researchers with West Virginia University and the grant-making agencies that made this innovation possible,” says John Clarkson, a member of the project team from USACE’s Huntington District. “It pays to partner.”

**Quest for New Resins Takes Flight**

**Project:** Next generation of aerospace resins

**School:** Western Washington University

**Location:** Bellingham, Wash.

**Principal Investigator:** David Rider

In February, Washington Gov. Jay Inslee visited the plastics and composites engineering facilities at Western Washington University (WWU). Students demonstrated a handful of research projects that could ultimately be commercialized by businesses throughout the state – music to the governor’s ears. One of the graduate students who caught Inslee’s attention was Ryan Hackler, who shared research on development of the next generation of resins for aerospace composites.

The project falls under the umbrella of WWU’s Partnership for Industry Research & Education (PAIRED) program. A team of students has partnered with Zodiac Cabin & Structures, a manufacturer of structural composites and aircraft interiors, to find a replacement for traditional thermoset resins used in composites. They are led by David Rider, assistant professor of chemistry and engineering, and Nicole Hoekstra and Nicole Larson, also professors of engineering.

“Thermosets are well-rooted in aerospace for good reason,” says Rider. “They are mechanically robust, and there’s plenty of research to guide the manufacturing process.” But Zodiac Cabin & Structures is forward-thinking. Certain compounds contained in resins and released during cure are considered hazardous air pollutants (HAPs) by the U.S. Environmental Protection Agency. “The threshold is becoming more strict over time, and there may be a time when we need to avoid phenol formaldehyde resins,” says Rider. “We’re trying to get Zodiac to the point where it has a backup resin system ready to go.”

WWU teamed up with Zodiac Cabin & Structures nearly three years ago, when the subsidiary of French company Zodiac Aerospace approached Rider’s team with a manufacturing issue. Due to stricter requirements, distortion or warpage needed to be more tightly controlled. University researchers and Zodiac Cabin & Structures audited the entire manufacturing process to improve the process. “That was a great starting point to our relationship because we saw everything the company did from start to finish,” says Rider. It also led to the resin research, which is funded by grants from the Joint Center for Aerospace Technology Innovation and Zodiac Aerospace.

Rider and his team hope to create a resin system that avoids specific monomers, namely formaldehyde and phenol. In addition, they want to frame a solution that has the least impact on Zodiac’s current manufacturing stream. “We don’t want the company to decommission equipment,” says Rider. “We want them to make use of processing techniques and solvents they already have in place.” Zodiac Cabin & Structures uses compression molding to fabricate parts.

WWU began its quest for an alternative resin with a bismaleimide polymer, which is mechanically robust and high modulus and has a high glass transition. The team has found a way to improve the thermal robustness – how much of the material can be retained at high temperatures – with an additive that is very low in concentration. Rider says .5 percent loading can increase the weight retention by approximately 10 percent.
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As concerns about brain trauma in football players increase, a partnership with Clemson University bioengineering and packaging science researchers, Innegra Technologies and B&W Fiber Glass could create the next generation of safer football helmets using composite materials. Innegra-based composites are already used in hockey sticks, kayaks, windsurf boards and other high-impact applications. The team will evaluate if composites incorporating Innegra H yarns could better protect athletes’ heads in contact sports as well.

Innegra H combines Innegra S fibers with either carbon, glass, basalt or para-aramid fibers to create hybrid yarns; the team is testing which hybrid would be most effective for impact resistance in helmets. Innegra S fibers are tough, lightweight thermoplastic olefin fibers that have a higher elongation at break than most standard reinforcement fibers, says Elizabeth Cates, vice president of research at Innegra. This makes Innegra H particularly effective at absorbing impact energy.

“The higher elongation at break means that when the primary reinforcement fibers fail, the Innegra S fiber is still intact and can hold the structure together – a significant improvement in safety for FRP composites,” Cates says. “Our hope is that this property will translate into more effective energy absorption and dissipation, so that less of the energy of an impact is transmitted through the helmet to the wearer.”

Currently, professional and collegiate athletes wear helmets made with polycarbonate of varying thicknesses, and only one company designs football helmets with composites, say the Clemson researchers. Cates explains that the outer shell of football helmets was designed to prevent skull fractures from contact, and because football helmets do prevent most skull injuries, little thought had been given to the effect of impacts to the brain.

John DesJardins, assistant professor in bioengineering at Clemson, notes that most improvements in football helmets have focused on padding or adjustments to the shape, not the shell materials. “Historically, the thought was that the shell was simply too thin to provide any effective impact protection, and the only way you could make it provide more protection was to make it thicker. Thicker means heavier,” says DesJardins. Researchers at Clemson are working on composite shell materials because they are light weight and can better protect athletes.

While Innegra tests bending stiffness and strength of the materials, DesJardins will conduct testing on the impact response of the composite laminates at Clemson with Gregory Batt, an instructor in the department of food, nutrition and packaging science, and Natalie Patzin, a masters student in bioengineering. Clemson’s tests consist of creating a high-intensity shock event generated by dropping a weight on a supported sample. The team uses an accelerometer to record the material’s response upon the weight’s impact. A high-speed camera visually slows down the impact event, allowing the team to capture the impact and rebound velocity for the calculation of the coefficient of restitution and measure the actual deflection of the composite sample. For now, testing is performed on flat panels; later the researchers will evaluate curved prototypes and, eventually, actual helmets.

The researchers plan to evaluate and categorize a wide range of composite configurations based on the Innegra fiber’s ability to absorb impact energy. “With composite materials, there are many different material design factors that can be used to make the optimum material for a particular application,” DesJardins says. “The greatest challenge in this project will be to use our initial testing data to select the specific material and composite design from which to produce candidate helmets for final testing and evaluation.”

The partnership is expected to last into early 2015. Innegra Technologies and B&W Fiber Glass, who together manufactured and commercialized hybrid yarns for the study, see opportunities...
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for the materials to be applied in a variety of areas in which safety is a concern. This includes sporting equipment and automobiles. “A football player’s head impacting the turf will be different than a whitewater kayaker’s head impacting a rock or a hockey player’s head impacting the ice,” Batt remarks. “There is clearly further work that could be done in pairing the best composite material for the variety of sport-related impact events that could occur.”

Lighter Containers, Heavy Results

**Project:** Composite shipping containers  
**School:** University of Bath  
**Location:** Claverton Down, Bath, England  
**Project Leader:** Heather Parker

A team of five graduate students at the University of Bath won first prize in the Energy Young Entrepreneurs Scheme (Energy YES) for their concept of using a lightweight composite material to replace heavy steel in walls of shipping containers. The team represented the Centre for Sustainable Chemical Technologies at Bath under the name Absol Composites. Its members were Heather Parker, Emily Hayward, Stephen Wood, Will Mahy and Jon Wagner.

Energy YES is a three-day British business competition organized by The University of Nottingham’s Haydn Green Institute for Innovation and Entrepreneurship (HGI) and the Network of Energy Doctoral Training Centres that aims to develop the entrepreneurial skills of energy research Ph.D. students and help solve challenges in the energy industry. This year’s competition brought together 50 researchers from 13 centers at 16 universities in the United Kingdom. Teams participated in a workshop to develop business plans for their energy sector-specific idea, then pitched their plans to a panel of judges, similar to the television show “Shark Tank.” As winners, Absol Composites received £1,000 (approximately $1,700) and the opportunity to bring its idea to Engineering YES, a similar competition that focuses on broader areas of research.

Heather Parker, Absol Composites’ student leader, described their concept as a theoretical process involving pre-fabricating flexible sheets of woven Kevlar-like fibers in an epoxy resin, which could be wrapped around a steel frame skeleton and cured in situ. “We anticipated that this would lead to a considerable reduction in manufacturing costs in comparison to conventional composites, which would make our process cost competitive with traditional steel container manufacturing,” Parker says. “In addition, the use of the existing container steel frames would make our process less disruptive than moving to 100 percent composite containers, thereby allowing an easier transition from steel to composite containers.”

The team’s concept was sparked after reading a March 2014 article in *The Economist* (“Boxing Clever”) that discusses how CFRP containers could help ease global shipping costs. A lighter container could make a big difference in shipping costs; 12 percent of the weight of a fully loaded steel shipping container is the container itself. After Parker and the team began their research, they found how much composites could really do to reduce the costs and carbon footprint of shipping. “Shipping companies are currently facing serious cost pressures, and a significant cost to them is their fuel usage,” says Parker. “One way of relieving some of this pressure would be to save fuel by using lighter containers. However, these still need to meet stringent ISO standards, which makes composites a particularly suitable steel replacement.”

The team found various advantages to using composite containers, including reducing fuel consumption, greater resistance to corrosion and security benefits, such as the potential to use “soft” X-rays at customs, rather than expensive, high-energy radiation. “The current level of composite development appeared to be approaching a level whereby [composites] might soon be commercially viable for use in [shipping] applications,” Parker notes.

Mary Beck is the communications coordinator at ACMA. Email comments to mbeck@acmanet.org.

Susan Keen Flynn is managing editor of *Composites Manufacturing* magazine. Email comments to sflynn@keenconcepts.net.
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Pipe and Tank Market Poised for Growth

FRP muscles in on metal for corrosion-resistant and sustainable applications. By Patrice Aylward

FRP pipe and tank installations are on the rise – above and below ground, in commercial, municipal and residential applications. As a result, many pipe and tank fabricators are witnessing a surge in business, particularly in the United States. “In the 1980s, the chemical processing industry was rationalizing. Some plants were shuttered, and many fabricators were forced to cut back,” says Jim Ness, corrosion and infrastructure marketing specialist for AOC LLC and a longtime consultant to the industry. “Over the last five years, we’ve seen new chemical facilities, horizontal drilling in shale fields and population growth creating demand for power and water. The low cost of natural gas is contributing to the development of new and the expansion of existing chemical processing plants.”

A look at the FRP pipe and tank market from 2013 – 2019 below confirms the positive outlook. In 2013, the North American FRP pipe and tank market was estimated at nearly $1.2 billion. Dr. Sanjay Mazumdar, CEO of Lucintel, says that the market promises considerable growth as a result of significant demands from industries such as oil and gas, wastewater, sewage, chemical, retail fuel and pulp/paper.

In the pipe market, oil and gas activities are strong as government and private oil companies are expected to invest more in new pipelines to transport refined products, crude oil natural gas and natural gas liquids such as ethane and propane, according to Lucintel. In addition, the increased production of shale gas also drives the market for FRP pipe, as does emphasis on pipe rehabilitation. Several factors are driving growth in the tank segment, including capital investment by end user industries, rehabilitation of old urban infrastructure and a rebound in the housing sector. Also noted is the trend to replace corroding, leaking tanks made of metal or concrete with FRP tanks.

Despite the optimism, the market faces challenges. The rising cost of materials such as borax, a key component in glass fiber, may present a drag on growth as it affects the total cost of FRP pipes and tanks; cost is already an obstacle that FRP pipe and tank suppliers must overcome. “We’re also being challenged by increasing environmental requirements,” says Ness. “Corrosion-resistant resins for FRP typically include cobalt in small percentages as an additive to aid in curing. Europe is already demanding cobalt-free equipment. They’d like us to take styrene out of the resin as well. There are some resins that are styrene-free, but they are not corrosion resistant.”

However, the benefits of the pipe and tank market far outweigh the challenges. There are several promising market segments for industry suppliers.

Rehabilitation Drives Water/Wastewater Projects

“Water and wastewater treatment plants continue to be a good market for us as municipalities, driven by U.S. Environmental Protection Agency regulations, are forced to make modifications such as switching from chlorine gas to liquid sodium.
Components of the reverse osmosis desalination plant in Carlsbad, Calif., include a 72-inch FRP raw seawater intake system, 42-inch backwater supply and 18-inch air scour pipe.

hypochlorite as an alternative treatment chemical,” says Steve Macy, president of Belco Manufacturing Co. Inc.

The need to upgrade and repair U.S. infrastructure, as well as an increase in construction activity, is spurring gains in the municipal market. Nassau County’s Department of Public Works provides an illustration of the pressing need to rehabilitate public water treatment systems. When Hurricane Sandy hit Long Island’s Western Bays, the Bay Park Sewage Treatment Plant was severely compromised, drawing attention to long-simmering infrastructure problems within the industry and the need for capital improvements. Currently, two Nassau County wastewater treatment facilities with a capacity for treating up to 142 million gallons a day of sewage – Bay Park and Cedar Creek – have five new FRP odor control systems under construction.

Given the expansive scope of fiberglass work under multiple contracts, three manufacturers are currently supporting the project – An-Cor Industrial Plastics, Perry Fiberglass Products and ZCL Composites through its ZCL-Troy division. Construction is underway and scheduled for completion in 2015. The odor control systems include ductwork ranging in size from 30 inches to 72 inches in diameter and 14-foot diameter dual bed carbon absorbers. Typical ductwork design conditions include ±15 inches of water column pressure rating, with temperatures of 40 to 100 F. Chemical storage tanks range from 4 feet to 10 feet in diameter, storing 12.5 percent sodium hypochlorite and 50 percent sodium hydroxide for feeding into the odor control wet scrubbing processes. All of the equipment is manufactured with a combination of filament winding, chop spray-up and hand layup.

**Boutique Water Projects on the Rise**

Water conservation is becoming an imperative in many regions of the U.S., leading to the growth of “boutique” markets for above ground and underground FRP tanks for residential and commercial applications ranging from 600 to 66,000 gallons and up.

Belco Manufacturing is located near Texas Hill Country, a 25-county region in south and central Texas that has endured drought conditions since 2007. “We’ve seen many homeowners
installing rainwater harvesting systems, particularly in remote areas away from the city,” says Macy. The systems accumulate rainwater for reuse. “Homeowners use it for fire protection and potable and non-potable water. This market is growing throughout the southwestern and western U.S.”

Xerxes Corporation, a ZCL Company, is another manufacturer of above ground and underground water tanks, including NSF-listed potable water tanks. NSF-certified products adhere to strict standards for public health protection set by NSF International, an independent testing organization. Xerxes’ installation of an underground water tank in the Sustainable Concept House in Boerne, Texas, helped the 3,600-square-foot house become one of the first in the San Antonio area to achieve Platinum LEED certification. Other recent Xerxes and ZCL water harvesting projects include a rainwater/storm water fiberglass collection tank for the University of Texas – Arlington and a 21,000-gallon fiberglass tank for Crystal Beach Campground on Prince Edward Island in Canada. “ZCL employs a range of hand layup, spray up and filament winding to manufacture, typically using spray chop for underground tanks as the external loading is higher,” says Richard Scragg, standards and design engineer for ZCL.

Containment Solutions, a provider of FRP tanks for water harvesting, recently supplied four FRP tanks to Binghamton University. Since 2013, 200,000 gallons of water have been retained in the tanks, making it the largest water harvesting project in western New York. These projects reflect the growing awareness of sustainability in regard to available fresh water supplies.

Seawater Desalination Begins to Unfold

In areas near seawater, the lack of fresh water is equally well documented, but the potential solution offered by FRP tank and pipe looks different than water harvesting. Conditions in California, Texas, Florida and elsewhere have driven desalination projects from their roots in the Middle East to the U.S. “In a sense, residential desalination is similar to oil field desalination,” says Ness. “Reverse osmosis (RO) is being used by the oil and gas industry to clean process water so it can be recycled to steam generators and injected back into the well. Similarly, seawater desalination, an RO process, is being used to make potable water for residential customers in arid environments.” Seawater desalination involves significantly more water than the oil and gas industry, requiring large engineering input and investment, adds Ness.

The long-term potential offered by desalination is evidenced by the request for proposal (RFP) issued by NineSigma, an open innovation provider representing the General Electric Company and the Saudi Aramco Entrepreneurship Center. The RFP calls for concepts to develop lower cost seawater desalination processes. According to NineSigma, Saudi Arabia is expected to invest $50 billion in water projects during the next decade. Globally, that projection is $300 billion. This represents significant market potential for FRP pipe and tank.

The largest reverse osmosis desalination plant in the western hemisphere is currently under construction in Carlsbad, Calif. The $1 billion, 50-million-gallon-per-day seawater desalination plant is the dream child of Poseidon Water, which partnered with the San Diego Water Authority to fund and build the project.

Ershigs Inc., a Denali company, provided the Carlsbad project’s general contractor with FRP pipe. The 2-inch to 72-inch NSF-certified pipe is filament wound using E-glass and vinyl ester as well as isophthalic resins for their corrosion resistance. Pipe flanges are manufactured using a hand-layup process. “The NSF certification is required as the pipe we are manufacturing for this project carries fresh water after it emerges from the reverse osmosis process,” says Steve Guay, Ershigs’ general manager.

Oil and Gas Markets Fuel Growth

“Right now, oil and gas extraction has legs,” notes Ness. Huge, developing shale fields in Montana, Pennsylvania, Ohio and Texas, for example, will require clean-up of the water coming out of the wells. The deeper the well, the greater the need for desalination. “As equipment suppliers come out with new methodologies and systems to handle waste streams, many of the systems are fiberglass,” says Ness. “FRP tanks and piping are being installed beyond the drilling environment and into refineries. And not just new tanks and piping, but larger tanks and larger diameter pipes as water recycling becomes more of an issue.”

The low cost of natural gas and the drive for energy independence inside the U.S. are long-term growth themes for FRP in the oil and gas industry. Freedonia Group’s October 2013 market report on world oil and gas pipe maintains, “As high oil prices and increasing demand for energy spur new development, increased oil and gas production will require additional
investment in pipeline infrastructure.” World demand for oil and gas pipe is expected to increase 5.3 percent per year, reaching 51.8 million metric tons in 2017. Freedonia cites increased offshore activity, deeper wells and the growing use of horizontal drilling techniques as contributors to growth, with higher pressures requiring increased pipe wall thicknesses.

Joie Folkers is director of sales for NOV Fiberglass Systems’ oil and gas market in the United States and a veteran of the composite pipe business since 1975. She says NOV and other suppliers are participating in another oil boom. Secondary and tertiary oil recovery, along with the technology used in shale plays, has made oil available where it was previously inaccessible. This, in turn, breathes life into the corrosion-resistance market.

“People are tired of corrosion, and corrosion is the problem FRP solves,” says Folkers. “In the past, steel was the king of material. Drillers just accepted that corroded metal pipeline would have to be regularly replaced.” FRP pipes offer a solution. And while fiberglass-reinforced polymer pipe may cost more per foot than steel, end users are beginning to recognize that despite higher upfront materials cost, the installed cost of FRP equipment is about the same. “Typically, the life cycle cost of fiberglass pipe is lower over the life of the installation,” says Folkers. “The life of the pipe will outlast the life of an oil field.” Plus, she adds, FRP pipe provides a smoother surface to allow fluids to flow more easily, lowering the energy required to pump them.

NOV is currently working on a new installation in northeastern Mexico, a carbon dioxide gathering system that will collect and move CO2 for use in tertiary recovery in oil fields. “Wet CO2 includes corrosive carbolic acid and so it needs FRP pipe,” says Folkers. Wells are drilled to extract the CO2 and gathered into progressively larger pipe. As more wells join the line, the CO2 is dried and sent in a long transmission line to Midland, Texas, and other sites for injection.

The Future of FRP Looks Bright

The expansive range of end markets for FRP pipe and tanks offers some strategic security to suppliers. “On the business side, the number of markets we participate in helps us smooth out our business cycles,” says Macy of Belco. “For example, some markets such as pulp and paper may be in a downturn, while oil and gas is growing here.”

The development of design software also has aided suppliers. “FRP manufacturers are faster than ever at going from idea to finished product, responding more quickly to customer needs,” says Ness. “In the past, we may have overdesigned and overbuilt products because value engineering was expensive. Not anymore.”

He points to the growth of composites engineering programs and research around the country as critical. “The more engineers who are exposed to FRP and get excited about it, the better,” says Ness. “Add in the development of standards and codes, such as the new pipe standard coming from the American Society of Mechanical Engineers in 2016, and the sense of reliability and stability for customers will continue to feed the environment for growth.”

Patrice Aylward is a communications consultant based in Cleveland. Email comments to paylward@aol.com.
CAMX Brings Strength and Innovation to Orlando

ACMA and SAMPE will showcase the best of the composites industry.

By Mary Beck

ACMA and the Society for the Advancement of Material and Process Engineering (SAMPE) have combined their strengths to produce The Composites and Advanced Materials Expo (CAMX), happening this Oct. 13-16 at the Orange County Convention Center in Orlando, Fla. As the premier event for the composites industry, CAMX attendees will discover new commercial and industrial applications for advancing the use of innovative materials as well as identify new products and geographic markets that can increase sales and boost a company’s bottom line.

ACMA had hosted COMPOSITES for more than 30 years, while SAMPE hosted its Annual Spring Convention for more than 60 years. In 2012, ACMA and SAMPE’s Boards of Directors voted to merge their respective annual conferences. They noted that their conventions had similar goals: Both wanted to reach all market segments and focus more on high-

Register now to reap all the benefits that CAMX has to offer!
The exhibit hall at COMPOSITES 2013 showcased a wide variety of market segments and business opportunities. There will be even more exhibits and opportunities – more than 500 exhibiting companies - at CAMX this October.

performance manufacturing. Now that the event is finally on the horizon, Tom Dobbins, president of ACMA, wants to provide “a first-class experience” for the attendees.

“We want to make sure that the people who attend this conference walk away with new insight, new knowledge, new ideas and inspiration for their next contribution to the composites industry,” Dobbins says.

Attracting more than 8,500 attendees and more than 500 exhibiting companies, CAMX will be more than twice as large as each of ACMA and SAMPE’s previous conventions. CAMX will showcase the best aspects of those conventions and introduce new programs, including an awards program to complement the Awards for Composites Excellence (ACE). CAMX is the place to explore new and unique business opportunities, learn, network and innovate. “If you want to meet anybody face-to-face who are critical players in the composite industries at any level, they are going to be in Orlando this October,” says Gregg Balko, CEO of SAMPE.

Wally Gutzmer, a sales associate at DeLong & Associates and Aksaca Carbon Fiber, came to a previous COMPOSITES show looking for two particular connections, but found far more than he’d expected. “I connected with the contacts I had planned to meet and also formed connections with several additional contacts, whom I had not expected to see there or whom I didn’t realize were interested in carbon fibers,” Gutzmer says.

“I’m looking forward to the new conversations a typical ACMA customer will be having with a typical SAMPE customer,” Balko says. “That’s where the real learning and the idea sharing is going to take place and some of the problems in manufacturing can be solved.”

Mary Beck is the communications coordinator at ACMA. Email comments to mbeck@acmanet.org.

CAMX provides members of the composites industry with countless opportunities to learn from each other. Be sure to stop by the ACMA booth (4478), where you can learn about ACMA’s member programs and meet ACMA members.

Visit www.theCAMX.org/Registration.php today.
CAMX will be more than double the size of COMPOSITES, so be prepared and have a conference plan! Here are some tips for what to do before arriving in Orlando – all of which the CAMX website can help you do.

**Awards and Product Displays**

ACMA will continue to present its Awards for Composites Excellence (ACE) and the ACMA Membership Awards. Hosted by ACMA, ACE is a prestigious composites industry competition that recognizes outstanding achievement and innovation in the categories of design, market growth and manufacturing. ACMA’s Membership Awards honor four individual members of ACMA with the Outstanding Volunteer Award, The Lifetime Achievement Award, Composites Hall of Fame Award and the Chairman’s Award.

In addition, a new CAMX Awards Program will celebrate cutting-edge innovations that show strength through collaboration, while bridging low-cost materials/high-volume applications with high-performance applications/low-volume materials.

Products from both awards programs will be on display at CAMX, allowing attendees to see the innovations first-hand. Composite parts from NASA and auto companies will also be on display.

**Keynote Speaker**

CAMX’s exhibit dates will kick off on the morning of Tuesday, Oct. 14 with a keynote address from Kevin Mickey, president of Scaled Composites. Scaled Composites is an aerospace and specialty composites development company with broad experience in air vehicle design, tooling and manufacturing, specialty composite structure design, analysis and fabrication and developmental flight tests of air and space vehicles. The company has worked on high-profile projects, including SpaceShipOne, the first privately manned spacecraft to exceed an altitude of 100 km (62 miles) twice within a 14-day period. This accomplishment earned Scaled Composites the $10 million Ansari X-Prize.

An industry veteran with more than 20 years of experience, Mickey’s keynote will inspire everyone to “dream it and build it.” Mickey will discuss topics such as the future of the industry, how to approach traditional material users on the conversion to composites and his experience of leading teams with the aim to instill entrepreneurial drive and culture.

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## Schedule at a Glance*

**Sunday October 12**
Registration Open  
1:00 p.m. – 5:00 p.m.

**Monday, Oct. 13**
Registration Open  
8:00 a.m. – 5:00 p.m.

Pre-Conference Tutorials  
9:00 a.m. – 12:00 p.m.

Pre-Conference Tutorials  
2:00 p.m. – 5:00 p.m.

SAMPE Awards Ceremony  
6:00 p.m. – 8:00 p.m.

**Tuesday, Oct. 14**
Registration Open  
7:00 a.m. – 5:00 p.m.

Conference Program  
8:00 a.m. – 9:00 a.m.

Opening Session, Keynote & CAMX Awards  
9:30 a.m. – 10:45 a.m.

Exhibit Hall Hours  
11:00 a.m. – 5:00 p.m.

Conference Program  
2:00 p.m. – 5:00 p.m.

Welcome Reception  
5:00 p.m. – 6:00 p.m.

**Wednesday, Oct. 15**
Registration Open  
7:00 a.m. – 5:00 p.m.

Conference Program  
8:00 a.m. – 12:00 p.m.

Exhibit Hall Hours  
9:30 a.m. – 5:00 p.m.

Conference Program  
1:00 p.m. – 5:00 p.m.

Market Segment Networking Reception  
5:00 p.m. – 6:00 p.m.

**Thursday, Oct. 16**
Registration Open  
7:00 a.m. – 4:00 p.m.

Conference Program  
8:00 a.m. – 12:00 p.m.

Exhibit Hall Hours  
9:30 a.m. – 12:00 p.m.

Closing ACMA and SAMPE Luncheons  
12:00 p.m. – 2:00 p.m.

Conference Program  
2:00 p.m. – 4:00 p.m.

*Schedule subject to change

Learn more and create your personal schedule of events at  
www.theCAMX.org/education.php.
No Autoclave, No Oven, No Problem!

Innovative out-of-autoclave solutions expand composite opportunities across market sectors.

By Melinda Skea

Out-of-autoclave (OOA) manufacturing has grown as a way to process next-generation structures, particularly in the aerospace industry. But what is leading manufacturers to adopt OOA, especially considering they've already invested so much capital in autoclave systems? It boils down to two main factors – money and part size. Traditional autoclave curing systems are expensive to buy and operate and are available in limited sizes.

Manufacturers in aerospace and other industries are increasingly turning to OOA to cure parts only in an oven. Out-of-autoclave is less capital-intensive and less costly, especially as parts increase in size and number. Several of the latest advancements push the technology even further, offering curing solutions that are out-of-autoclave and out-of-the-oven. Among the solutions under development are integral liquid heating and induction heating. These technologies offer the same benefits of OOA and then some – fewer steps, less material and shorter cycle times.

The Argument for Out-of-Autoclave

OOA is most heavily utilized by aerospace industry manufacturers. However, seen as a solution to the drawbacks of autoclave processing, a variety of sectors are adopting OOA methods, from renewable energy to automotive and consumer electronics. They hope to improve their products, increase throughput, cut down on production time, and decrease capital, operating and labor costs.

Autoclaves are capital intensive: The price of a single autoclave often runs six figures. Those costs can skyrocket even higher, particularly in aerospace where bigger parts lead to larger autoclaves and larger price tags. “In 2007, NASA looked into what it would cost to acquire a 40-foot diameter autoclave, and the cost came out to $100 million, including installation,” says John Russell, technical director of the Manufacturing and Industrial Technologies Division at the Air Force Research Laboratory. “For parts that aren’t frequently replicated, that is a cost we can’t justify.”

Dale Brosius, president of Quickstep Composites in Dayton, Ohio, says autoclave also has long turn around and cycle times, which takes expensive equipment out of the equation for too long, further increasing costs for manufacturers. This applies to new parts as well as part repairs. “Bondet/heater configurations are more economical through focused and localized heating of a repaired part,” says Eric Casterline, president of HEATCON Composites Systems in Seattle. “OOA avoids heating the whole part (automobile, aircraft etc.) during a repair operation.”

OOA also allows for faster production of parts. “Long-term success of carbon fiber [reinforced polymer] will require higher rate production methods not possible with autoclave,” says Brosius. “For example, the build rate for next-generation fighter aircraft will increase to one per day, which is well above historical production rates.” He adds that the next iteration of the Boeing 737 will need to be produced at rates of 45 per month, much higher than the Boeing 787’s required production of 15 per month. “To create lighter, more fuel-efficient aircraft, the next

Expliseat’s Titanium Seat was developed using RocTool’s 3iTech technology. Working with Hexcel, Tencate and A&P Technology under the guidance of Expliseat, the new aircraft seat is less than half the weight of its competition and is considered the most efficient economy-class seat for the Boeing 737 and Airbus 320, according to the companies. It is also the first composite aircraft seat to pass dynamic 16 G-force crash tests while reducing fuel consumption estimated at $500,000 per year per aircraft.
generation will also have a very high composite part count,” says Brosius. “And that puts pressure on every level of the composite manufacturing supply chain.”

Curing times are the industry’s biggest bottleneck, says Michael Rauscher, chief technical officer of NONA Composites in Dayton, Ohio. The company’s name is an abbreviation for the solutions it offers – no oven, no autoclave. “To hit higher production rates and drive down cost, we must address curing times,” he says. It is such an important issue to manufacturers that companies are sending employees to trade shows in search of new OOA processes, says Benjamin Luedtke, technical manager for Quickstep Composites.

This doesn’t mean that OOA is the silver bullet for further composite adoption. Each market segment requires qualifications for new products and materials, and these qualifications mean an investment in both capital and time. On the scale of testing stringency, aerospace ranks highest, taking years to approve a new material and/or process, then automotive, renewable energy and other growing markets, such as consumer electronics and medical equipment. “If the volumes are low, qualifying a new process may not be worth it,” explains Brosius.

OOA Advancements and Applications

French company RocTool, with U.S. headquarters in Charlotte, N.C., has been at the forefront of innovative OOA systems. The company uses induction heating to create aerospace parts and internal car parts, such as textured trim pieces for the new Mini Cooper. A growing part of its business is in consumer electronics, where RocTool won an industry award as part of the Motorola Mobility team for the composite rear housing of the new Motorola Moto X smartphone.

In 2000, the company began changing OOA methods with a resistive heating process where electricity would go through the fiber and heat the resin as well. Then RocTool evolved to its Cage System® with inductors around the mold to heat the entire surface. “It was an interesting process, but we were limited in the materials we could use,” says Mathieu Boulanger, business development director for RocTool.

Four years ago the company released 3iTech® with induction coils integrated in channels that can heat the tool very quickly. In June, RocTool introduced a light induction tooling (LIT) molding system. It features a metallic female mold and a male silicone mold. Unidirectional or woven fiber reinforcements are placed in the female mold, the male mold is closed, and then pressurized air is injected into the mold up to 420 psi. The LIT system heats up to 280 C in 45 to 90 seconds depending on the material and part. Water then cools the mold and part in one to two minutes. “The LIT system requires no preheating, provides a resin-rich surface, requires no resin injection, allows for thin walls and offers good temperature control,” says Boulanger.

With each of these developments, Boulanger points out that RocTool never considered autoclave or oven systems. “We are focused on reducing steps, and OOA is the best option,” Boulanger says. RocTool continues to improve its processes and demonstrate a variety of temperatures (useful to produce various parts) and an increase in manufacturing speed. “If a cycle time...
Out-of-Autoclave in the Military

Perhaps the most successful demonstration of large out-of-autoclave manufacturing is the Air Force Research Laboratory-Lockheed Martin X-55A Advanced Composite Cargo Aircraft. Using a Dornier 328 cut off behind the cockpit to bypass new flight control expenses, Lockheed Martin added a 60-foot composite fuselage comprising eight pieces. This allowed the company to manufacture a military transport representative airplane in only 18 months while adhering to a $50 million budget.

Since its successful completion, others have followed in its steps. “Boeing built the Phantom Eye that uses a significant amount of OOA,” says John Russell, technical director of the Manufacturing and Industrial Technologies Division at the Air Force Research Laboratory. “Commercial aircraft are also looking into OOA, because they realize you can make bigger parts that cannot be made in the current largest autoclave.”

The Defense Advanced Research Project Agency (DARPA) is conducting testing that will eventually reduce the number of specimens needed to qualify a part for aerospace applications. Its results will be considered the “holy grail” for manufacturers in the defense industry. “If we can cut down the number of tests without increasing risk, it would lower the hurdle for companies to look at new materials,” says Russell.

Despite all of the research and development efforts conducted by the military and defense sector, most organizations are in a holding pattern. “A lot of decisions are determined by the federal budget,” says Russell. “There are studies being done on the next-generation mobility airplane, bomber and fighter. The Department of Defense will determine if it will build new aircraft or repair existing ones.” Russell adds if the military requires new aircraft to replace C-5s and C-17s or a replacement for the B-52 or B-1, then OOA is a great solution because of the large size those aircraft are projected to be. “However, if it’s a fighter plane, I don’t see the need for OOA,” he says. “The parts are small enough to use the existing autoclaves in the industrial base.”

is more than 30 minutes, we wouldn’t look at it,” says Boulanger. “Most of our cycle times are between two and eight minutes. And one of the best things is that whereas in past years we were considered exotic, today people are comfortable working with us.”

Meanwhile, Quickstep Composites utilizes integral heating/cooling for curing composite materials, primarily used in aerospace. With the company’s heat transfer fluid (HTF) process, the laminate is placed between a rigid or semi-rigid mold that floats in an HTF. A flexible membrane separates the mold and laminate from the circulating fluid, which can be quickly heated and then cooled to cure the laminate.

While conventional autoclave processing cures at 100 psi and requires long cycle times, Quickstep’s heat transfer fluid process enables precise control of process temperature throughout the curing process, says Luedtke. The process utilizes existing autoclave-qualified preregs so as to limit recertification costs.
On one prepreg system, the process has demonstrated the ability to cut cycle times from 20 hours to four hours. “Because it can accurately control the mold temperature and its increased ramp rates, it saves on process time, energy costs, investment and overall component manufacturing costs,” says Luedtke.

In 2010 Quickstep teamed with Vector Composites on a research project to demonstrate the ability to cure CYCOM 977-3 unidirectional epoxy prepregs to aerospace standards. These processes were accepted, and now the project has moved to the next phase – preparing laminate parts for testing. Test results are expected by summer 2015.

Quickstep also is making inroads in the automotive sector with its resin spray transmission process (RST), an automated, fast-cure system for composites requiring a Class A surface. “There are companies in Europe that we’re working with to create OOA parts,” says Luedtke. “This process hasn’t taken off in the U.S. yet because it isn’t under the same pressure as Europe, but it’s the goal.”

A Look Ahead

OOA is evolving to address application problems ranging from part size, manufacturing costs, part quality and curing time. It also is adapting across sectors, including aerospace, automotive, renewable energy, consumer electronics and even farm equipment. However, in order to keep up with the growing demand for composites across industry sectors, manufacturers need access to more CFRP. “CFRP is being sucked up by the aerospace industry and not a lot is left for everyone else,” says Luedtke. “Because they can’t access high-quality carbon fiber, companies are turning to natural fibers such as jute and hemp, and natural resins such as corn, soy and even cashew shells.”

Casterline adds that training also is important to the growth of OOA applications. “There needs to be overview education for middle and senior management, technical skills training and possibly an industry standard certification for technicians,” he says.

Melinda Skea is a freelance writer based in Washington, D.C. Email comments to mskea@icloud.com.
A variety of materials were showcased amongst the nearly 1,000 exhibitors at the 2014 American Institute of Architects (AIA) Convention in Chicago, but the composites exhibits had a special highlight. They were the only booths housed under a canopy of the materials they promoted to the nearly 20,000 attendees at the convention in June. ACMA proudly hosted the first-ever Composites Pavilion at the AIA Convention, with a CFRP and GFRP canopy designed by award-winning architect Greg Lynn and fabricated by Kreysler & Associates.

Hanging from the ceiling above the Composites Pavilion, the canopy was designed to draw the crowd to the pavilion and provide a focal point for the area. “I was hoping [the canopy] would represent an object that was so uniquely made out of composites that wasn’t possible to do with any other material, and I think it accomplished that,” says Bill Kreysler, president of Kreysler & Associates and chair of ACMA’s Architectural Division. “It did attract attention, and it set apart the pavilion from all the other exhibits.”

The 20 x 16 x 5-foot canopy contains two GFRP structural rings, a smaller inner ring at the bottom and a larger outer ring higher up. Ninety-six CFRP ribbons arch out like water in a fountain, connecting the two rings.

The ribbons, made from unidirectional carbon fiber, were each 50 millimeters wide and one millimeter thick. The pieces were cut to length based on a computer model. A CNC machine was used to create the mold for both GFRP rings, which were fabricated using hand layup and featured a polyester laminating resin. More than 350 zip ties secured the intersections of the ribbons. Josh Zabel, director of digital fabrication at Kreysler & Associates, fabricated the canopy and helped install it at the convention.

The canopy had to meet all building code requirements, so it could not
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More than 40 companies belong to ACMA’s Architectural Division, which strives to promote the use and understanding of architectural FRP composites in construction. By changing codes and creating specifications, the group works to make FRP composites an acceptable alternative to traditional materials. It also educates architects and building officials. For more information or to join, contact Andrew Huber, Manager of ACMA’s CGI Committees, at ahuber@acmanet.org.

Mary Beck is the communications coordinator at ACMA. Email comments to mbeck@acmanet.org.
How Hazardous are Your Waste Management Practices?

By John Schweitzer

Composites manufacturing operations routinely generate and dispose of waste materials. Because this is a routine operation, manufacturers can find the actual handling of waste materials has drifted from the company’s standard procedures, placing the plant at risk of safety incidents and compliance problems.

Federal regulations define all “garbage, refuse and sludge” as solid waste. Also, any “solid, liquid, semi-solid or contained gaseous material,” which is “discarded, served its intended purpose or is a manufacturing byproduct” is a solid waste. Composite manufacturers typically find that their scrap resins, overspray, discarded molding compound and other similar materials are solid wastes.

To determine if a solid waste also is a hazardous waste, under federal regulations the waste generator asks the following: Does the solid waste exhibit the characteristics of ignitability, corrosivity, reactivity or toxicity? Is it a listed waste? Is it a mixture that contains a listed waste?

A solid waste that is a liquid exhibits the characteristic of ignitability if it has a flash point below 60 °C. Scrap resins are captured under this definition and are therefore considered hazardous waste under federal regulations. Scrap molding composites are typically not considered hazardous waste because under federal regulations, they are not considered liquids. Few industry wastes are listed wastes, contain listed wastes or exhibit characteristics other than ignitability.

As soon as a generator forms an intent to discard a material, it becomes a solid waste subject to federal regulation. If the waste is or contains a listed waste, or if it exhibits the characteristics of ignitability, corrosivity, reactivity or toxicity, then it also becomes a hazardous waste, and the generator is subject to the applicable requirements for hazardous waste generators.

Federal regulations contain several requirements that apply to generators of hazardous waste, including requirements for obtaining Environmental Protection Agency ID numbers, manifests, packaging and labeling; limits on accumulation time; and record keeping and reporting. However, a conditionally exempt small quantity generator – defined as generating no more than 100 kilograms of hazardous waste in a month – is generally exempt from the requirements for hazardous waste generators.

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Further, generators who accumulate waste on site for 90 days or less prior to treatment or transport off-site are not required to have permits as treatment, storage and disposal facilities. Ninety-day generators, however, are required to store the waste in containers, tanks, containment buildings or on drip pads that meet certain standards. They also must comply with certain requirements for labeling tanks and containers, for testing and maintenance of equipment, and for contingency planning and emergency procedures.

In response to an ACMA petition, in 1997, the EPA approved polymerization for the treatment of scrap resin, at the site of generation, without having to obtain a waste treatment permit. The polymerization must occur in tanks, containers or containment buildings, and these units must comply with the standards for so-called 90-day generator tanks, containers and containment buildings. A written waste analysis plan is required, and the amount of scrap resin that is polymerized counts toward the amount of waste generated monthly. Generators should ensure that the resulting polymerized resin does not itself exhibit the characteristic of ignitability; many composite manufacturers who use polymerization to treat resin break open the drums to ensure that no ignitable liquids remain.

Generators of hazardous waste must generally comply with the same Occupational Safety and Health Administration regulations that apply to manufacturers who handle the same materials. For example, scrap resin management activities must comply with the same permissible exposure limits and hazard communication requirements as resin processing operations.

ACMA members can find more information about waste management requirements and practice at http://acmanet.org/regulatory-compliance/waste-regulatory under the Member Resources tab.

John Schweitzer is vice president of government affairs for ACMA. Email comments to jschweitzer@acmanet.org.
Inside ACMA

Growing Stronger Every Day

Your association is more important to your company than ever. The scope and success of CAMX – and our partnership with SAMPE to bring this fabulous show to the industry – underscores ACMA’s strengths. First, it highlights our commitment to supporting the development of your business. The whole mission of CAMX is business development. Our tradeshow floor is the largest ever for composites in North America. Add to that more than 250 educational sessions, and attendees will gain the technical support and expertise they need to take their companies to the next level.

CAMX also shows off another of ACMA’s strengths: our ability to unite the industry and foster its growth. Working with SAMPE and other major industry groups, ACMA is devoted to growing the industry by educating engineers, architects and designers at OEMs to specify composites.

The 12 committees comprising ACMA’s Composites Growth Initiative program also are working on expanding the industry. In addition, the association serves as your representative to harness government resources and grow the industry. ACMA has been active in the development of two industry roadmaps to identify new markets for composites and find ways to penetrate those markets. We also worked with the Department of Energy to launch an Advanced Manufacturing Institute for Composites. There will be an important presentation on the new institute at CAMX. I hope you can participate!

We can do even more to help grow your business, but we need two things. First, we need your continued membership to have the resources to represent you. Even more
importantly, we need your participation. As the old adage goes, “Ninety percent of success is showing up!” Learn about the benefits that active ACMA members receive by attending a CGI Committee meeting at CAMX.

It is time to check out all that CAMX, ACMA and our Composites Growth Initiative have to offer. Join your industry peers and discover how together we can grow stronger every day.

Tom Dobbins, CAE
ACMA President

ACMA Supports Road Mapping Initiatives

Earlier this year, the National Institute of Standards and Technology (NIST) announced two awards through its Advanced Manufacturing Technology Consortia (AMTech) program that will have a direct impact on the future of U.S. composites manufacturing. These grants, given to the Georgia Tech Research Corporation and the University of Massachusetts at Lowell, are designed to establish and strengthen industry-focused research consortia and to develop shared vision technology roadmaps of industry research needs.

When combined with the enormous opportunity offered by the emerging $150 million Clean Energy Manufacturing Innovation Institute for Composite Materials and Structures, these activities offer the promise of a broader dialogue and shared vision for the composites community that will enable it to compete more effectively with incumbent solutions in markets like automotive, renewable energy or infrastructure. There are also opportunities for individual businesses to benefit from this investment. ACMA has been involved in shaping the vision for the institute and the roadmaps with a number of composites industry partners.

To learn more about these initiatives, contact ACMA President Tom Dobbins at tdobbins@acmanet.org.

Green Composites Council Begins Pilot Projects on Recycling

The Recycling Committee of the Green Composites Council has begun two pilot projects to address the repurposing of scrap glass fiber and composites. The first pilot project will involve testing hundreds of pounds of scrap glass fiber to determine if it can be recycled into a new material. The second pilot project will involve recycling composites. Several methods are being explored, including using recycled composites as filler in thermoplastics and concrete.

ACMA’s Affinity Program Is Growing

We continue to add great offerings to our Affinity Program. ACMA’s affinity program provides our members with a wide array of products and services at a reduced rate. Visit acmanet.org/opportunities/affinity-programs to learn about all of the benefits available to you.

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ACMA Calendar of Events
For more information regarding ACMA’s upcoming events and education, visit acmanet.org/meetings.

September 23-24
CCT-Instructor Course
Dayton, Ohio

October 7-9
COMPOSITES EUROPE 2014
Messe Düsseldorf, Germany

October 13-16
CAMX – The Composites and Advanced Materials Expo
Orlando, Fla.

November 12-13
CCT-Instructor Course
ACMA Headquarters
Arlington, Va.

December 9-11
CompositesWorld Carbon Fiber 2014
La Jolla, Calif.

March 23-27, 2015
The International Plastics Showcase (NPE)
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Every two years, teams from across the globe race solar-powered boats on a 200 km route—approximately 125 miles—during the DONG Energy Solar Challenge in Holland. The SCIGRIP Solar Boat Team, composed of Polish engineers in the marine industry, has been a fixture at the competition since the first race in 2006. It placed second and third in previous years and won the Innovation Award for the lightest boat in the regatta in 2012. The team won the championship in the July 2014 race.

Team members built the boat themselves to ensure maximum efficiency. It features a carbon fiber epoxy sandwich construction using polyethylene terephthalate (PET) foam as the core material. The team uses a selection of methyl methacrylate (MMA) adhesives from SCIGRIP for all bonding. “Gluing the bulkheads, engine column and deck-to-hull instead of laminating them cuts the weight of the boat and speeds up the building process, which gives us more time for sea trials,” says Michal Wawrzeniak, the boat’s helmsman and repairman.

The SCIGRIP Solar Boat Team builds a new boat for every race, always aiming to improve performance and lightweight construction. Despite barely docking from the most recent race, they’ve already started brainstorming new ideas and improvements for 2016. For more information on the SCIGRIP team, visit scigripsolarboatteam.com.
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