What's Ahead in 2019 and Beyond:

State of the Industry Report

Trends in Thermoplastics

Gaining Ground in Mass Transportation
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Materials with Mass Appeal ..........................9
Opportunities are opening up for composites in rail and other mass transport applications as end users seek a mix of properties that FRP provides, including lightweighting, design flexibility and fire and smoke retardancy.
By Mary Lou Jay

What does 2019 – and beyond – have in store for the composites industry?
In this year’s annual State of the Industry report, experts offer insight into six specific areas – two main reinforcements, two primary market segments and two regions of the world.

Trends in Reinforced Thermoplastics.......22
Thermoset resins dominate the composites market, but thermoplastics are gaining traction. Check out five key developments in the ongoing evolution of thermoplastic composite materials and processes.
By Melissa O’Leary
Learn Something New in the New Year

The beginning of a new year is a time to start fresh – and not just with personal resolutions. As 2019 kicks off, consider what you can do to enhance your career, your company and the composites industry as a whole.

In November, I spoke to a group of emerging student leaders at my alma mater, Ohio University. (Go Bobcats!) I provided the young adults advice on moving from the College Green – the university’s central lawn – to the C-suite in a corporation. One of the things I suggested was that the students continue to learn long past graduation and throughout their careers. As the new year begins, I encourage you to do the same: Make it a goal to add to your skill set by learning something new.

ACMA strives to be the industry thought leader and provide plenty of learning opportunities through its events, the Certified Composites Technician program and publications like Composites Manufacturing magazine. So start your learning in 2019 with this issue. Discover a new potential marketplace for your company’s products and services: Opportunities in the rail and bus industries are discussed on page 9. Find information on five key developments in thermoplastic composites and how they are gaining traction in the industry on page 22.

A few years ago, Core Molding Technologies entered the niche market of long fiber thermoplastic compression molding – direct inline compounding of reinforcing fibers and thermoplastic resins at the point of molding. As a provider, you need a broad offering of solutions, and we saw thermoplastics as a market that offered opportunities.

If you want to discover more industry opportunities, don’t miss our annual State of the Industry report on page 14. It offers great insight that you can build on this year when ACMA releases the first set of products in its composites statistics program, which will provide insight on polyester and vinyl ester FRP composites.

The new year looks bright. Turn to ACMA for a wealth of educational resources that will help you learn something new and make the most of 2019.

Sincerely,

Kevin Barnett
Core Molding Technologies
ACMA Chairman of the Board
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Until recently, manufacturers of plastic and FRP parts had limited choices for Class A in-mold coating solutions and, as a result, had to rely heavily on post-mold, liquid-applied coatings. In the case of automotive applications, choice of in-mold coatings were virtually non-existent. Thanks to recent advancements in coating chemistry and metering technology, parts manufacturers can now deliver cost-effective, direct-from-mold Class A plastic and composite parts that meet stringent automotive OEM validation requirements while offering a broad range of attractive design options in terms of colors, textures, haptics and other attributes.

Millions of molded plastic parts requiring a Class A finish are produced by the industrial and automotive supply chain every year. Historically, post-molding application of decorative coatings requires extensive and costly capital equipment and generates high levels of scrap and waste, such as overspray solids/filter media and VOC emissions. Post-mold coating processes also add logistics and handling costs.

Today, advancements in chemistry and metering technology allow the application of multi-component coatings for high-volume part production directly in the mold. This process is generically referred to as Reaction Injection Molding (RIM) overmolding. The RIM overmolding process involves injecting a multicomponent coating, which reacts or polymerizes directly within a closed mold at relatively low pressure.

Following the molding of the part, the tool is rotated or indexed to present the freshly-formed part to the A side tool, which includes the features and finish (e.g. matte/gloss, textured, etc.) desired on the exposed surface of the part. The A side of the RIM mold (cavity) and its offset from the formed substrate in the core mold determine the film thickness and the A surface finish. A highly-polished cavity mold for the RIM shot delivers a glossy surface, while a matte finish delivers a dull surface finish. This highlights another unique capability of this technology – delivering glossy or matte surface finishes in the same part without masking or assembly steps.

Pressures during the RIM overmold process at the injection port are typically between 15 psi and 30 psi, with a peak pressure at the injection port of approximately 150 psi. These pressure ranges are relatively small as compared to the clamp loads required by the substrate forming process and therefore typically do not influence press sizing.

This process of injecting a low viscosity material (similar to water) at low pressure into a closed mold has a number of distinct advantages, which are particularly relevant to composite parts producers. For example, the coating process surface being defined predominately by the A side mold allows manufacturers to overcome substrate variations that would otherwise require extensive priming and sanding operations. This feature alone enables better surface
quality, reduced defects and greatly reduced operating costs.

Thanks to significant advancement in polyurethane coating chemistry, RIM coating systems are now available that deliver automotive OEM levels of scratch/mar and environmental exposure performance, while including integrated mold release agents that enable high-volume automated production of parts. The concurrent development of precise and repeatable metering systems with modular color change capability was a key enabler for commercialization of this process.

In addition to meeting stringent durability performance requirements, RIM coating technology is also economical. The total cost of a part on the vehicle is cost competitive with the highest performance post-mold, liquid-applied coating systems available today. To estimate an apples-to-apples cost comparison, the analysis needs to extend beyond the cost per gallon, pound or kilogram. RIM coating technology benefits from a near 100 percent transfer efficiency and is a 100 percent solids coating system, which means that virtually all of the material ends up on the part/vehicle and not as overspray or emissions (VOCs) released into the atmosphere.

A recent study conducted by a global automotive OEM demonstrated significant cost/save potential compared to its current plastic parts coating process. The study noted that cycle time, process steps and scrap rates are dramatically reduced compared to conventional spray painting. These insights were a key driver in the OEM’s decision to begin the transition to RIM overmolding of targeted plastic parts that are currently painted. As many innovative technology providers are painfully aware, for a new product or technology to gain traction in the competitive high-volume industrial and automotive markets, a capable supply base is required. Ruhl Strategic Partners has partnered with the following technology providers to establish the RIM Coating Technology Center in Livonia, Mich.: Hennecke Inc. provides its Colourline Metering System with multicomponent ratio control and color change capability, along with technical support to oversee future demonstration and development programs. Votteler brings to the partnership a broad portfolio of OEM-approved RIM coating systems, including a broad palette of colors, haptics and effects. The RIM Coating Technology Center is located in SA Engineering’s Research, Demonstration and Development (RD&D) facility, which features Engel Injection Molding Technology.

For more information on RIM overmold technology, visit the RIM Coating Technology Center website at rimtechcenter.com.

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A mong the 1,695 new attendees at CAMX 2018 in Dallas last fall was Quang Truong, an architect who is fascinated by composite materials. Truong studied both art and engineering at Dartmouth College as an undergraduate student, then earned his master’s degree in architecture from Yale University. He now runs his own studio in Portland, Ore.

Truong, who has been practicing architecture for approximately 15 years, teamed with an engineering and manufacturing company that specializes in advanced composite materials several years ago to build a dream home for an owner using structural FRP components. He is currently working with a publisher to write a book on composites in architecture.

“There are lots of textbooks featuring technical and engineering information, and there are great industry publications put out by ACMA and JEC,” says Truong. “But I saw a gap in the literature for a publication that prominently features the architectural design possibilities of composites.” After CAMX, Composites Manufacturing magazine’s Managing Editor Susan Keen Flynn caught up with Truong to talk about those possibilities.

Q: Do you recall when you first heard about composites?

A: Well, I played tennis when I was growing up, right around the time that companies were experimenting with composites in their racquet frames. There was a brief moment where wood racquets were still in people’s memory, metal was still commonly used and graphite composites were just starting to appear. ... That and my lifelong love of cars meant that I always was aware of composites. But it was through a series of graduate courses at Yale, one with architect Greg Lynn and one with architectural historian Mario Carpo, that I really started to dive into both the technical and theoretical potentials for composites as a building material.

Q: When did you first incorporate composites in a professional project?

A: For a residence that I built in New York which, for various reasons, was designed in a way that was only possible to build with composites. I think it was a fortunate circumstance where the architect, contractor and owner were all on board with making that vision a reality.

Q: Can you tell us a bit about that project?

A: I can’t say too much about it, but I know that at the time it was built, there was no other structure like it – a monocoque structural FRP roof and exterior enclosure. That’s what is exciting about architectural composites right now. Each building that uses [the material] does so in a way that is unique. I think that as other architects begin to use composites, each will find their own way to use them that speaks to how they see the material solving a problem or achieving a certain design goal. The Apple buildings are certainly doing it in a certain way, with a specific vision for how the material can expand architectural possibilities. [Apple’s headquarters in Cupertino, Calif., and Chicago’s flagship store both feature CFRP roofs.] And I’m excited to see how other architects explore composites as well.

Q: Have you used composite materials again since then?

A: It really has to be the right combination of many factors for composites to be a viable architectural proposal – as it is with any material – and I haven’t been in that situation again where I felt like it was the right solution for the particular architectural situation. Because of that, I’ve actually taken to designing a carbon fiber chair just to be able to work with the material again. I’m excited for when the opportunity presents itself again to use composites in a building. I think right now my dream would be to do a building that involved both mass timber and composites.
Q: Tell us about one of your more interesting subsequent projects.

A: Since the completion of that residence that used structural FRPs, I’ve actually been involved in a few mass timber projects and gotten a broader understanding about the use of nonconventional building materials in the construction industry. What’s interesting about composites and mass timber is they both attempt to address specific goals in the building industry, seemingly from different ends of a spectrum, but share many of the same challenges to wider adoption. Through studying materiality – and maybe through practice in general – I’ve gained a broader appreciation for the role of architecture in our time.

Q: What attracts you to composite materials?

A: It’s been a part of everything I loved as a child – tennis, cars and airplanes. I also think composite materials are one of those things where you can explain the basics of it to anybody, but then there is a seemingly bottomless well of information about it if you want to dive in deep. Of course, once you explain the basics of composites to somebody, it also immediately begs the question of why they aren’t used more in architecture. And that’s when it gets complicated – when you have to explain why it isn’t so easy to use composites in architecture. I think part of what I love is that challenge – making something that is complicated uncomplicated.

Q: What kinds of architectural projects are composites ideally suited for?

A: Because composites can be engineered to have all sorts of properties, many of which will perform much better than conventional materials, they are ideally suited for all sorts of architectural applications. But realistically, they are best suited for projects where the owner and contractor have a familiarity with composites and are aligned on the vision and aware of the challenges with implementation.

Q: So how do you overcome the challenges?

A: I think it all starts with communication. If there is clarity in the discussion about costs versus benefits, advantages versus challenges, then people can get aligned on paths forward, if that is the decision that makes the most sense for people. Without that clarity in communication, it’s hard to know where to begin – for anybody.

Q: What can the composites industry, as a whole, do to further composites usage within the architecture segment?

A: From my perspective as an architect, I think that what people need to see is the potential design opportunities that composites provide. The most resonant message is an image that expands their idea of what is possible and entices them to begin the process of discovery on their own. That is why I’m writing a book about composites that is geared toward designers, architects and the more general public, featuring buildings that use composites by world famous architects. My hope is that it goes a long way toward clarifying and elucidating the potential for composites in architecture.

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

Marine

Ship Propeller Shows Promise

Made with carbon fiber composites, the 2.9-foot prototype propeller developed by the FABHELI consortium performed well during stringent in-water tests.

Military and civilian markets generally have different requirements when they commission products made from composite materials. But the French consortium FABHELI had to meet the needs of both groups when producing a 2.9-foot, CFRP propeller prototype. It succeeded in developing a propeller that has the potential to decrease ships’ energy consumption and maintenance costs, improve their hydrodynamic efficiency and cut their acoustic emissions. Plus, the propellers could be manufactured at a price that would appeal to both military and civilian shipbuilders.

FABHELI comes from “fabriqué,” short for fabricated, and “heli,” the French word for propeller. Loiretech, a designer and manufacturer of composite tooling, leads the consortium. Its partners include NAVAL Group, a designer/builder of naval submarines and surface ships, and Méca, which makes innovative composite structures. Subcontractors included Bureau Veritas, a provider of testing, inspection and certification services, and the AML shipyard, which supplied the test vessel for the new propeller.

In this two-year project, the consortium demonstrated several advantages of composite propellers over metallic ones. One was fuel savings, which is important both to military customers and to civilian markets. Fishermen, for example, spend 80 percent of the money they make on each trip for fuel.

To develop an efficient design, the consortium used adaptive profile computing to calculate and then test, using simulations, the effects of the flow of water (hydrodynamic behavior) and the rotation of the blades on various propeller designs.

There are three major components to the blade. “The leading edge is very important, because it has to separate the flow of water,” says Franck Bourcier, Loiretech’s vice president of marketing and innovations. “The second thing is the surface of the blade, because you must always have contact between the blade and the water. If you lose contact at certain moments, you lose accuracy, which is what we are looking for. You must also have a very thin trailing edge to avoid cavitation; the thinner the trailing edge, the better the result will be and the more efficient the blade will be.” (Cavitation is the development of bubbles in liquid caused by the movement of the propeller.)

The military was particularly interested in the composite propeller’s potential to reduce cavitation and thus acoustic emissions, which would make it harder for an enemy to track a ship using sonar. A proprietary coating on the blade helped dampen this noise as well.

Another project goal was to come up with a design that would allow a single diver to change propeller blades. That’s currently a difficult, two-person task.

“The challenge was to develop an innovative junction between blades and...
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root, which can be dismounted and adapted to the resin transfer molding (RTM) process,” says Samuel Durand, senior structural engineer and manager at Méca. “Junctions and connections are often the weakest point in composite materials, and for a marine propeller the loads at this junction are huge.”

The solution was to add an integrated, overmolded insert to the foot of each blade and then attach the blades with eight large screws to the metal hub. The composite propeller is light enough for one diver to maneuver.

The consortium manufactured the propeller using RTM, starting with three dry fiber preforms, one for each side of the propeller blade and one at the foot for the connection. Lay-up operations were optimized by calculating the number and orientation of carbon fibers in specific areas to fulfill the hydrodynamic strength requirements for the blade.

The team developed a custom lightweight composite for the core of the blade and added carbon textile at the leading and trailing edge for added impact resistance. These net shape edges don’t need trimming, so there is less waste. The team chose an epoxy resin to provide stiffness and because it is not susceptible to the oils found in harbor waters.

The Bureau Veritas supervised the composite propeller design and manufacture in preparation for future certification that could allow the propeller to be sold on the commercial market.

Last March, at the AML shipyard in Lorient, France, the propeller was installed on Le Palais, a 95-foot, 84-ton ferry ship that can carry 286 passengers. The propeller performed well on its inaugural 10-mile trip to Groix and then on a 200-mile journey to Brest and back.

“The shipyard owner is used to metallic blades, and they weren’t sure that the composite blades could succeed at the mechanical requirements,” Bourcier says. The boat’s crew tested the propeller under difficult conditions, going in reverse at full speed and making sharp turns without any damage.

“That was a big surprise to them; we were able to prove that the concept blade was stiff enough to meet the requirements,” he adds. “They are now believers and want to be involved in the next project.”

The consortium is also partway to achieving its affordability goal. According to its calculations, metallic propellers would be cheaper than composites if less than 30 are purchased, but composites have the advantage if that number is over 50.

The consortium would like to build another prototype so it could replace both metallic propellers on the Le Palais with composite propellers and better measure the reduction in cavitation. It also hopes to build a 13-foot diameter propeller and perhaps design a composite crankshaft that would further improve efficiency. Bourcier adds that future development of the propeller will depend on the funding that the consortium is able to secure.

Mary Lou Jay is a freelance writer based in Timonium, Md. Email comments to mljay@comcast.net.
For more than 50 years, thermoset composite producer Norplex-Micarta has done a steady business in manufacturing materials for mass transit applications, including train and light rail braking systems and electrical insulation for overhead rails. But today, the company’s markets are expanding beyond that relatively narrow niche into other applications like walls, roofs and floors.

Dustin Davis, Norplex-Micarta’s director of business development, sees an increasing number of such opportunities in rail and other mass transit applications for his company and other composites manufacturers and suppliers in the coming years. There are several reasons for this anticipated growth. One is Europe’s adoption of fire standard EN 45545-2, which imposes more stringent fire, smoke and toxicity (FST) requirements on mass transit. Using phenolic resin systems, composites manufacturers can incorporate the necessary fire and smoke-retardancy properties into their products.

In addition, bus, subway and train operators are beginning to realize the benefits that composite materials offer in reducing noise vibration and harshness. “If you’ve ever been on a subway, you’ve heard that metal panel that is rattling,” Davis says. “If the panel is made from a composite material, it tends to dampen that sound, so you get quieter trains.”

The lighter weight of composites also makes them attractive to mass transit operators interested in reducing the use of fuel and/or extending their operating range.

Materials with Mass Appeal

Composites are moving into new applications for rail and bus travel.

By Mary Lou Jay
Composites Manufacturing

Composites Manufacturing
Market research company Lucintel agrees with Davis’ predictions on composites’ greater role in mass transit. In a September 2018 report, Lucintel projected that the global market for composite materials for mass transportation and off-road vehicles will grow at an annual rate of 4.6 percent between 2018 and 2023, reaching a value of $1 billion by the end of that period. The opportunities will come in a wide variety of applications, including exterior, interior, under-the-hood and powertrain parts and electrical components.

The new parts that Norplex-Micarta is now producing are currently being tested on light rail lines in the U.S. In addition, the company continues to focus on electrification systems, taking continuous fiber materials and joining them with faster curing resin systems. “You can lower the cost and increase the output and bring the full capabilities of an FST phenolic to market,” Davis explains.

While composites can be more expensive than similar metal parts, Davis says that cost isn’t the deciding factor in the applications they are working on. “We are focused on areas where we can displace other materials that just don’t meet the customers’ requirements,” he says. “We are looking at providing a functionality enhancement.”

Lightweight and Fire-Retardant

The renovation of European railway operator Duetsche Bahn’s fleet of 66 ICE-3 fast trains is one example of composite materials’ ability to meet customers’ specific needs. The installation of air conditioning systems, passenger entertainment systems and new seating added unwanted weight to the ICE-3 rail cars. In addition, the original plywood floors didn’t meet the new European fire standards. The company needed a flooring solution that could help it shed the added weight and comply with the fire standards. Lightweight composite flooring was the answer.

Composite fabrics producer Saertex, based in Germany, provided its LEO® material system for the floor. LEO is a layered, non-crimp fabric that offers higher mechanical properties and greater lightweighting potential than woven fabrics, according to Daniel Stumpp, head of global marketing at the Saertex Group. The four-component composite system includes a special fire protection coating, a glass fiber reinforcement, SAERfoam® (a core material with integrated 3D-glass fiber bridges) and the LEO vinyl ester resin.

Composites manufacturer SMT, also located in Germany, manufactured the flooring in a vacuum infusion process, using reusable silicon vacuum bags made by the English company Alan Harper.

“We save about 50 percent in weight [from] the former plywood panels,” Stumpp says. “The LEO system, being based on a continuous-fiber laminate with a non-filled resin system, has an excellent mechanical performance … . Furthermore, the composites don’t rot, which is a big advantage, especially in regions where it snows in winter time and the floors get very wet.” Both the floor panels and the carpet and rubber materials on top meet the new fire retardancy standards.

SMT produced more than 32,000 square feet of panels, which have so far been installed on about a third of the eight-wagon ICE-3 trains. Each panel size is being optimized during the refurbishment process to fit a particular car.

The OEM for the ICE-3 cars, which was not involved in the floor refurbishment process, was so impressed by the new composite flooring that it has ordered composite roof segments to replace the old metal roof structures in the rail cars.

Going the Distance

California-based Proterra, a designer and manufacturer of zero-emission electric buses, has been using composite materials for all of its bus bodies since 2009. In 2017, the company’s Catalyst® E2 bus set a world record by traveling 1,100 miles on a single battery charge. That bus featured a lightweight body built by composites manufacturer TPI.

Recently, the collaboration between TPI and Proterra has produced an integrated monocoque composite electric transit bus. “In a typical bus or truck, there’s a chassis and the body is placed on top of that chassis,” explains Todd Altman, TPI’s senior director of strategic markets. “With the monocoque design for the bus, we are integrating the chassis and body, similar to a uni-body car design.” The single structure is more effective than two separate structures in meeting performance requirements.

The Proterra monocoque body is purpose-built, designed from the ground up to be an electric vehicle. Altman says
that’s an important distinction, given the experience of many automakers and electric bus manufacturers that have tried with limited success to adapt their legacy designs for internal combustion vehicles to electric vehicles. “They take their existing platform and try to put in the batteries wherever they can. That does not yield the best solution from a variety of standpoints,” Altman says.

For example, many electric buses have batteries mounted in the rear or on the roof of the vehicle. But for Proterra, TPI was able to mount the batteries underneath the bus. “If you’re putting a lot of weight on a vehicle structure, you want that weight to be as low as possible both from a performance standpoint and from a safety standpoint,” Altman says. He notes that many manufacturers of electric buses and cars are now going back to the drawing board to develop more efficient, purpose-built designs for their vehicles.

“When people come to a composite manufacturer, they may say, ‘Build this part or this small subsystem,’ and you’re in a box. In these cases, you are often pushed into limited design flexibility. That can result in utilizing more of a higher-cost material like carbon fiber than you would have if you could build with sandwich construction and develop a design that’s more optimal,” Altman adds. “That’s where purpose-built really comes in; you can design a solution that doesn’t have the same number of tradeoffs that you would have if you tried to make the body from something else.”

TPI has signed a five-year agreement with Proterra to produce up to 3,350 composite bus bodies in TPI’s factories in Iowa and Rhode Island.

**Customization Needed**

Designing the Catalyst bus body required TPI and Proterra to continually balance the pluses and minuses of all the different materials so that they could hit cost targets while achieving optimal performance. Altman notes that TPI’s experience with producing massive wind blades almost 200 feet long and weighing 25,000 pounds has made it relatively easy for them to produce 40-foot bus bodies that weigh between 6,000 and 10,000 pounds.

TPI was able to get the required structural strength by employing carbon fiber selectively, reserving it to reinforce areas carrying the heaviest loads. “We use carbon fiber in those places where it can essentially buy its way onto the vehicle,” Altman says. Overall, carbon fiber makes up less than 10 percent of the bus body’s composite material reinforcement; the remainder is glass fiber.

TPI chose vinyl ester resins for similar reasons. “When we look at epoxies, they are fantastic, but when you cure them you have to elevate the temperature so you have to heat the molds. That’s an added expense,” he continues.

The company uses vacuum-assisted resin transfer molding (VARTM) to produce a composite sandwich, which provides...
the necessary stiffness for the monocoque body. Some metallic fittings, such as threaded fittings and tapping plates, are incorporated into the body during the manufacturing process. The bus is molded in two parts – upper and lower – and then bonded together. There are a few small composite trim pieces, like fairings, that workers have to add later, but the number of parts is a fraction of what it would be on a metal bus.

Once the completed body is sent to the Proterra bus production factory, the manufacturing line flows much faster because there is less work to be done. “They don’t have to do all the welding and grinding and manufacturing, and they have a really simple interfacing to attach the body to the drive train,” Altman adds. Proterra saves time and reduces its overhead because there’s less manufacturing space needed for the monocoque body.

Altman believes that demand for composite bus bodies will continue to grow as cities turn to electric buses to reduce pollution and cut costs. According to Proterra, battery-electric vehicles have the lowest operational lifecycle (12-year) cost when compared to diesel, compressed natural gas or diesel-hybrid buses. That could be one reason why Proterra says that sales of battery-powered electric buses now claim a 10 percent share of sales for the total transit market.

There are still hurdles to wider adoption of composite materials for electric bus bodies. One is the specialization that different bus customers demand. “Every transit authority likes to get their buses differently – the seat configuration, the way their hatches open. This is a big challenge for bus manufacturers, and many of these configuration items can flow down to us,” says Altman. “Composite bus body manufacturers want to have a standard build, but that’s difficult to do if each customer wants a high level of customization.” TPI is continuing to collaborate with Proterra to enhance the bus design to better manage the end customer’s desired flexibility.

Exploring Possibilities

Composites companies are continuing to test their materials for new mass transit applications. In the United Kingdom, ELG Carbon Fibre, which specializes in technologies to recycle and reuse carbon fibers, is leading a consortium of companies in the development of a lightweight composite rail bogie frame for a passenger train car. (A bogie is known as a railroad truck or truck in North America.) Rail bogies support the car’s body, guide the wheelset and maintain its stability. They help increase ride comfort by absorbing vibrations from the track and minimizing the effect of centrifugal forces as the trains round curves.

One objective of the project is to produce a bogie that’s 50 percent lighter than a comparable metal bogie. “If the bogie is lighter, it will do less damage to the tracks, and that will reduce the time and cost of maintenance because the load on the track will be lower,” says Camille Seurat, product development engineer at ELG. Additional objectives are to reduce lateral wheel-rail forces by 40 percent and also provide through-life condition monitoring. The British non-profit Rail Safety and Standards Board (RSSB) is funding the project with the goal of producing a commercially-viable product.
Magma Structures is responsible for the design and build of the bogie and has carried out extensive manufacturing trials, building numerous test panels using press molding, conventional wet lay-up, infusion and autoclave cured prepreg. As the bogie will be a limited production run, the company has selected epoxy prepreg materials cured in the autoclave as the most cost-effective build method.

The full-size bogie prototype will be 8.8 feet long, 6.7 feet wide and 2.8 feet high. It will be manufactured from a combination of recycled carbon fiber (a non-woven mat supplied by ELG) and virgin carbon fiber fabric. Unidirectional fiber will be utilized for the main strength elements, and this will be laid in the molds using robotic technology. The epoxy resin, chosen for its good mechanical properties, will be a newly-formulated, fire-retardant epoxy resin that has been qualified under EN45545-2 for use on the railways.

Unlike a steel bogie, which is made from a transom beam welded to two side beams, the composite bogie will be manufactured as distinct top and bottom sections and then bonded together. In order to replace an existing metal bogie, the composite version will have to incorporate, in the same location, suspension and brake attachment brackets and other fittings.

“For the moment, we chose to keep the steel fittings, but for further projects it could be interesting to replace the steel fittings with composite fittings so we can reduce the final weight a little more,” Seurat says.

One consortium member, the sensors and composites group at the University of Birmingham, is overseeing the development of fiber optic monitoring sensors that will be integrated into the composite bogie at the manufacturing stage. “The majority of the sensors will be focused on monitoring strain at discrete points on the bogie and others on temperature sensing,” Seurat says. The sensors will allow real-time monitoring of the composite structure, allowing lifetime load data to be collected. That will give valuable information on peak loading and long-term fatigue.

Initial studies have shown that the composite bogie should be able to achieve the desired 50 percent weight reduction. The project team hopes to have a full-sized bogie ready for testing in mid-2019. If the prototype performs as predicted, they will produce more bogies for testing on rail cars made by the rail transport company Alstom.

Although there’s still much work to be done, initial indications show that it would be possible to produce a commercially-viable composite bogie that could compete in cost and strength with metal bogies, according to Seurat. She adds, “[After that,] I think there are plenty of options and potential applications where composites could be used in the rail industry.”

Mary Lou Jay is a freelance writer based in Timonium, Md. Email comments to mljay@comcast.net.
2019 State of the Industry Report
A snapshot of key materials and markets in the global composites industry.
Although composites battle with traditional materials like steel and aluminum for market share, they are gaining traction worldwide. The global composites market size is expected to reach $130.8 billion by 2024 and expand at a compound annual growth rate of 7.8 percent over the forecast period, according to a report by Grand View Research Inc.

What does 2019 – and beyond – have in store for the composites industry? That’s admittedly hard to nail down considering the industry comprises such a vast range of raw materials and end-use products. In this year’s annual State of the Industry report, experts offer insight into six specific areas – two main reinforcements, two primary market segments and two regions of the world.

The Glass Fiber Market
By Dr. Sanjay Mazumdar, CEO
Lucintel

The composites industry is enjoying its ninth successive year of growth, with significant opportunities across numerous vertical markets. Overall, the U.S. composites industry provided opportunity valued at $25.2 billion in 2018 for a wide variety of products, including rebar, wind blades, pipes, tanks, bath tubs, automotive components and more. As the major reinforcing material, glass fiber is helping to drive that opportunity.

The glass fiber market grew by 2.9 percent in 2018, reaching 2.5 billion pounds in terms of volume and $2.1 billion in terms of value. Glass fiber demand for the U.S. is expected to reach 3 billion pounds by 2024, with a compound annual growth rate of 2.8 percent.

With regard to supply and demand, global glass fiber capacity was 10.9 billion pounds in 2018 and is currently running at 91 percent utilization. (See Figure 1.) Fiberglass plant capacity will increase in 2019 as several major glass fiber producers build new plants throughout the world.

Owens Corning is expanding its glass fiber production capacity in Chambery, France, which will help the company fulfill growing demand for thermoplastics in Europe. The company also entered into a strategic cooperation and supply agreement with Chongqing Polycomp International Corp. (CPIC) for joint investment in technology, construction and operation of a new manufacturing facility for high-modulus glass fiber products in China. With an annual production capacity of 110,000 metric tons, the new facility is expected to be operational by mid-2019 and will help serve the growing wind energy market.

Other glass fiber suppliers expanding their capacity include Jushi China and Nippon Electric Glass Co. Ltd. (NEG). Jushi China is building a 200,000-ton capacity plant in Egypt and has set up a production plant in South Carolina with 80,000 tons of capacity that was expected to come on-stream by the end of 2018. In 2017, NEG acquired the U.S. glass fiber business of PPG Industries to expand its presence in the United States.

As more OEMs utilize composites, the future of GFRP looks promising. There are many applications – rebar, window profiles, utility poles, leaf springs, etc. – where composites penetration is less than 1 percent. Investment in technology and innovation will help grow the composites market significantly in such applications. But that will require the development of disruptive technologies, significant collaboration among industry companies, reinvention of value chains and new ways of selling composite materials and end-use products.

The composites industry is complex and knowledge-intensive, with hundreds of raw material product portfolios and thousands of applications. Therefore, the industry needs to identify and prioritize some big-volume applications based on synergy, capability, innovation potential, opportunity size, competitive intensity, profit potential, sustainability and other factors to drive growth. Transportation, construction, and pipe and tank are the three major segments in the U.S. composites industry, representing 69 percent of the total volume used.

Overall, the glass fiber industry has significant potential to grow as it accounts for a small fraction of the total structural materials market, where materials such as steel and aluminum continue to reign. To gain a competitive edge over traditional materials, the industry needs to focus on several key areas, including the following:

- Education of engineers and designers about the benefits of composites for mass-volume markets such as civil engineering, automotive, and pipe and tank.

![Figure 1: Global Glass Fiber Demand and Capacity](image-url)
• Development of cradle-to-grave infrastructure similar to steel and aluminum by addressing repair and recycling issues with composites.
• Development of mature advanced manufacturing processes targeting 1- to 2-minute cycle times for mass-volume markets.
• Reduction of material and parts costs to make composite parts competitive with steel and aluminum parts.
• Development of disruptive technologies to gain competitive advantage in terms of life cycle and performance benefits.

The Carbon Fiber Market
By Daniel Pichler, Managing Director
CarbConsult GmbH

The market for carbon fiber continues to grow at 10 to 15 percent per year. In 2018, global demand for carbon fiber totaled approximately 85,000 metric tons. Last year’s growth was led by incremental volume gains in carbon fiber use in aerospace programs, wind turbine blades and a variety of industrial applications.

Continued growth at this rate is expected for the foreseeable future. Aerospace and wind blade applications each made up about one-fifth of the market, while automotive and sporting goods accounted for approximately one-sixth each. The remaining 25 to 30 percent of the market comprised a variety of applications, including compounding for injection molded plastics, pressure vessels, construction and infrastructure reinforcement, tooling, marine, and oil and gas. All segments are growing as additional applications and programs come into production.

Industry capacity for carbon fiber production is tightening. Industry nameplate capacity (the rated capacity) may be 140,000 metric tons, but given the mix and variety of products produced and knock-down effects inherent in the process, effective industry net capacity is only around 100,000 metric tons. Therefore, we are currently seeing several new plants and capacity expansions coming on stream both from long-time producers and new players. New capacity is coming on line in all regions – in the U.S. (e.g., Alabama and South Carolina), in Europe (e.g., France) and in Asia.

China, representing 20 to 25 percent of world demand for carbon fiber, has another new player, but the country still has some catching up to do capacity and production-wise: Chinese producers have 12 to 15 percent of the world’s nameplate production capacity, but are producing less than 5 percent of the world’s carbon fiber. Chinese companies have well-resourced aims of doing more themselves. With demand for carbon fiber expected to break through 100,000 metric tons in 2019-2020, additional capacity is to be expected.

The acceptance of CFRP in any application depends on demonstrating both technical and economic benefits. In most applications, the main technical benefits of carbon fiber derive from the high strength-to-weight performance of the material, leading to lower weight structures. For example, a steel automobile body in white (a car with stamped sheet metal components welded together) might weigh 400 kilograms. However, the body could weigh just 100 kilograms if constructed from CFRP, which would lead to improved fuel consumption and carbon dioxide performance in gasoline and diesel-powered vehicles, or significantly extend the driving range of battery-powered electric vehicles.

All end-use segments of the market show significant potential for growth. Aerospace, wind turbine blades, sporting goods and molding compounds are well established end uses and will continue to grow as more and more programs are engineered to use carbon fiber. Pressure vessels (for compressed natural gas, liquefied petroleum gas, hydrogen, etc.) and construction and infrastructure applications are newer end uses and have significant growth potential as the benefits and construction methods are further pioneered. Automotive applications have the highest market potential, with so many applications and vehicle platforms in development to extend beyond the current early adopters. A future market scenario could look very different from today’s should development and adoption continue at current pace. (See Figure 2.)

The economic challenge for mass adoption of CFRP in everyday automobiles produced by the millions has yet to be solved, but the potential is huge. With both the cost of carbon fiber and the manufacturing cost of CFRP parts expected to come down as a result of adoption for mass production applications and increased use of automation, the opportunity for carbon fiber in automotive applications is almost unimaginable. High-volume production will result in lower costs and increased acceptance.

In conclusion, the market for carbon fiber and carbon fiber composites is growing steadily and robustly. Demand has
caught up to available capacity, and additional new capacity is coming on stream. In new mass-market applications, such as automobiles, as well as construction and infrastructure, the right materials used in the right ways will bring about further growth in demand. For carbon fiber, the future remains bright.

**The Infrastructure Market**

Dr. Hota GangaRao, P.E.

Wadsworth Distinguished Professor,
West Virginia University

Economic growth in the U.S. has been enabled through investments in infrastructure, but a funding gap has evolved that threatens future growth and the rate of growth. Over the next 10 years, the American Society of Civil Engineers (ASCE) projects a $1.4 trillion funding gap between revenue and needs, and failure to substantially close this funding gap will lead to $3.9 trillion of losses in U.S. gross domestic product, 2.5 million fewer jobs and cost each household $3,400 per year due to poor infrastructure.

Fiber-reinforced polymer composite products and associated systems can effectively rehabilitate or retrofit in-service U.S. infrastructure at a fraction of replacement costs, or they can lead to more economical replacements compared to conventional construction materials in areas of high corrosion. FRP composites have inherent advantages, such as corrosion resistance, durability, magnetic transparency, high strength and high stiffness-to-weight ratio. Composites also offer significant economic advantages. For instance, FRP composite wraps can be used to rehabilitate steel, concrete or timber substructures at about 5 percent of the cost of replacement. Similarly, the use of FRP rebar in place of steel changes the total project cost by only 1 percent, while substantially increasing the durability of concrete structures.

FRP wicket gates, which serve as movable dams on rivers, provide an excellent case study for the use of composites. For more than 150 years, wicket gates were built with large, durable old-growth timbers. However, the lack of availability of old-growth timber has led to an increase in maintenance costs and loss of durability. An FRP wicket gate was designed and tested by West Virginia University (WVU), manufactured by Composites Advantage and installed by the U.S. Army Corp of Engineers (USACE) on the Illinois River in 2015. It has been performing very well since. Not only is the durability expected to increase from 15 years to over 50 years with FRP, but the initial cost was two-thirds the cost of timber gates, according to a representative of the USACE.

However, overall use of FRP in infrastructure applications is only about 1 percent of total structural materials by volume. In April 2018, academic experts, ACMA representatives and government personnel testified to the Committee on Science, Space and Technology (Subcommittee on Research and Technology) of the U.S. House of Representatives. The testimony included several key areas that must be addressed for composites to gain additional market share, including the following:

- Developing new composite materials and systems with a focus on initial costs, durability, fire resistance, ease of erection and retrofitting in-service structures.
- Developing smart manufacturing of composites to retrofit existing infrastructure and mass produce new modular systems, resulting in high labor productivity and high-quality finished products.
- Initiating development of uniform codes, standards for manufacturing, retrofitting, construction, evaluation and maintenance, including stringent enforcement of standards.
- Bundling federal and state government-directed infrastructure projects to be considered with composites as alternative designs.
- Appropriating nationwide funding for preventive maintenance and repair using FRP composites to help save in-service infrastructure systems instead of replacing them.
- Offering hands-on training using composites and other training tools for 3.2 million construction workers in the U.S.

The United States is home to two out of five glass production factories and produces about a third of the world’s carbon fibers, including those spun from coal pitch. The export market of U.S. composites is expected to grow to about 4.9 percent annually by 2022, particularly with higher grade composite products. Thus, the composites industry in the U.S. is well positioned to expand into the infrastructure market.

However, the infrastructure market depends primarily on bidding of materials and associated systems, including design, which are developed by relying on codes and specifications. Broad expansion into infrastructure requires cooperation with ASTM International to develop testing standards, as well as the development of standards and codes with ACMA, USACE, ASCE, the American Association of State Highway and Transportation Officials, state Departments of Transportation and others. It is imperative for manufacturers, contractors and end users to work together to ensure high-volume use of composites in infrastructure markets.

**The Automotive Market**

By Marc Benevento, Managing Director

Industrial Market Insight

Nearly 4.5 billion pounds of composite materials are sold into automotive applications on an annual basis. The vast majority of this volume are thermoplastic composites,
which generally have lower material and processing costs than thermoset materials. Drivers for composite consumption in the automotive industry are, in the most basic form, vehicle production and the ability to win applications from materials such as steel and aluminum.

For composite applications currently specified on production vehicles, the amount of material consumed is proportional to the number of units produced. Global vehicle production growth is expected to be modest in 2019 and the near future, with annual growth rates of about 2 percent. Most unit production growth is anticipated to come from China and southeast Asia, with mature markets, including the United States and Western Europe, relatively flat. Therefore, composites will need to win new applications from steel and aluminum to realize significant volume growth.

The competition for applications on mass production automobiles is fierce, with materials winning based on the value they provide in terms of cost versus performance and weight. Because a primary driver of composite material selection is weight savings, the priority OEMs place on weight reduction will be paramount to future adoption of composite materials. Regional fuel economy standards and adoption of electric powertrains will play a crucial role in the future of composites in the automotive market.

Fuel economy standards and emission limits have been a primary driver of lightweight material adoption on new vehicles in the recent past. Lighter vehicles require less energy to start and stop, improving fuel efficiency. As a result of higher fuel economy standards imposed through 2021, aluminum and higher strength steel content in light vehicles has increased sharply, along with rising use of and interest in GFRP and CFRP.

Stringent fuel economy and emission regulations from 2020 to 2022 will continue to drive demand for lightweight materials. (See Figure 3.) Europe is the established center of the automotive composites world due to government and consumer incentives for small, lightweight and efficient vehicles. The United States and Canada are the only countries with established regulations beyond 2022, but the United States is currently considering relaxing regulations after 2021. Less challenging fuel economy regulations would remove incentive for adoption of lightweight composite materials in North America, which would ensure that composite technology leadership and material consumption remains elsewhere.

The emergence of new technologies in automobiles will also factor into future demand for composites in the industry. The impact that electric powertrains and autonomous vehicles will have on automotive materials are subjects of great debate at the moment. Electric vehicles have large batteries that must be enclosed to provide protection from the environment and road debris. Driverless cars will change the way people interact with vehicles and create new demands and desires for interior features. The timing and magnitude of these technological shifts will dictate whether these are attractive opportunities for composites in the short or long term.

There continues to be great opportunity to expand the market share of composites in the automotive industry. In the short term, the need for lightweight structures to aid in meeting rising regulatory hurdles will drive new applications of composites. Although a relaxation of fuel economy standards in the United States could serve as a barrier to the adoption of composites in the short term, the introduction of electric powertrains and autonomous vehicles will create a new wave of opportunity for these materials. Uncertainty around the timing and magnitude of that opportunity is a source of apprehension for OEMs and material suppliers alike.

The Chinese Market
By Ray Liang, Ph.D.
Managing Director, NSF Center for Integration of Composites into Infrastructure

With more than half of the world’s total construction taking place in China, the country is a leading driver of composites. For the past decade, the huge demand for advanced
Glass fiber production has arrived at a capacity of 3.85 million metric tons, with Jushi, Taishan and Chongqing producing more than 60 percent of that total. There are approximately 5,000 companies involved in composites manufacturing in China, leading to shipment of 4.62 million metric tons of glass fiber composites annually.

Chinese industry began to research, develop and commercialize carbon fiber about 35 years behind industrialized countries, and the market is still in its infancy. The Chinese government and industry started to invest in the production of carbon fibers in 2000. In 2017, there were only seven companies capable of producing more than 1,000 tons of carbon fiber per year to meet China’s domestic markets. Big gaps exist between the Chinese carbon fiber industry and industrialized countries in terms of quantity, quality, performance and variety of applications. Currently, CFRP composites in China are almost equally consumed for sports and leisure products and general industry, such as wind energy, automotive, transportation and construction.

Despite a late start in the market, Chinese carbon fiber production reached a shipment level of 5,700 metric tons in 2017, along with imported carbon fiber, to meet a domestic market demand of 23,487 metric tons. The future looks bright as China boasts the largest production of polyacrylonitrile (PAN) fibers, which will allow PAN-based carbon fiber and the composites industry to continue to expand in the next decade and beyond.

Growth of the Chinese composites industry, along with remarkable market penetration, offer tremendous opportunities for overseas companies. Consider the Chinese wind energy market, for example: The industry in China has grown at an average annual rate of 41 percent for the past 10 years, reaching a total installation of 188 gigawatts (GW) in 2017. The industry is targeting a total installation of 200 GW by 2020, with 30 GW being offshore installations. All major wind energy companies have operations in China, including Vestas, GE, Siemens Gamesa and LM Wind Power.

In 2019, domestic demand for glass fiber in China will continue to be strong, and several leading companies are installing more automated production lines to further address demand and lower long-term production costs. The Chinese composites industry anticipates a turning point in two years, when domestic carbon fiber production will surpass the imported amount. Several companies will have production lines for high-performance grade carbon fiber (T700/T800/T1000), and they have plans to address technical challenges to ensure that domestic products are competitive with imported products.

To promote wider use of composite materials, the Chinese composites industry is researching low-cost design and manufacturing technologies, structural multifunction integration technologies, environmentally-friendly materials, repair and retrofitting technologies, and recycling technologies. The industry will also benefit as the advantages of composites are more widely disseminated, especially among downstream end users. In addition, automated production, modernized management and large-scale production, coupled with strict quality assurance and quality control and the continuing expansion of various markets, will surely enable the Chinese composites industry to grow at double digits annually for next decade.

**The European Market**

By Elmar Witten, Managing Director

AVK, the German Federation of Reinforced Plastics

The composites industry is enjoying its sixth successive year of growth, increasing again by 2 percent to an estimated total of 1.14 million metric tons compared to the previous year. (See Figure 5.) As in past years, the volume of GFRP manufactured in Europe reflects trends observed in various market segments. Production of thermoplastics, used primarily in the automobile industry, is generally still growing more strongly than production of most thermostet materials.

Although GFRP production in Europe continues to grow,
its volume still lags behind the global market trend. Production volumes in Asia and America, in particular, have been growing at well over 2 percent in recent years.

An analysis broken down by country highlights various trends within Europe. There are major differences between regional markets which require individual analysis. For example, GFRP processing in Germany has a strong focus on the transportation sector and the electro/electronics industry. By comparison, the infrastructure market is thriving in Turkey, while the oil and gas industry is strong in Norway and Sweden.

On a positive note, production did not decline in any European regions reviewed. The southern European countries of Spain, Portugal, France and Italy are all reporting above average growth rates this year. Since 2012, the production volume in Spain and Portugal has clearly stabilized, and the recent trend has been upward. Germany continues to be the European leader in composites, with a total production volume of 229,000 metric tons in 2018. While Germany retained the leading position, its growth lagged behind the overall market trend.

Market growth in eastern European countries is above average at 2.5 percent. In the Benelux countries (Belgium, the Netherlands and Luxembourg), Scandinavia, Austria and Switzerland, reported levels remain unchanged and thus below average. Production in the United Kingdom and Ireland grew by just 1.3 percent.

Despite the difficulty of predicting future trends, it is possible to identify more general tides and currents that have the potential to influence ongoing development of the GFRP market. The automotive sector, for example, is currently undergoing major changes. While challenging, these changes present opportunities for manufacturers to choose and invest in new materials. In addition to being light, GFRP offers a wide range of advantages for many segments of the transportation sector, including electro mobility. Additional advantages include reduced energy consumption, durability and minimal maintenance. Composites are also nonconductive and offer excellent performance at a relatively low cost.

Alongside established materials used in series production, such as SMC/BMC and thermoplastics, established continuous processes, such as pultrusion, are again becoming a focus of attention.

Various market segments also offer hope for an increase in GFRP production. GFRP has the potential to play a greater role in antenna construction and building cladding. Composites already play a key role in lightweight construction concepts used in the growing aerospace sector. The energy sector is also expanding, becoming increasingly important over recent years. This trend will continue for years to come.

Due to their versatility and exceptional suitability for combination with other materials, GFRP and other composites offer outstanding potential in many applications. However, awareness of the materials is still too limited for them to be widely considered by decision makers. This must change because composites are often a good, if not better, choice. If customers can reassess these materials and composites become subject to standards/norms, then European market growth is assured for the coming years at an even faster rate than already experienced.

**Figure 5: European GFRP Market in Kilotons**

Source: AVK

More Industry Insight at ACMA Forum

For the latest composites industry insight, be sure to attend ACMA’s Composites Executive Forum in Annapolis, Md., June 25-27, 2019. Industry-leading executives will gather for management strategies, industry trend information and networking. For more information, contact Heather Rhoderick at hrhoderick@acmanet.org.
Trends in Reinforcement
For years, reinforced thermoplastics have been used in the automotive market, mostly for non-structural, interior components. But thermoplastic composites are advancing into new applications – and markets – as manufacturers strive for lighter, tougher parts that can be rapidly produced, post-formed and recycled.

“Thermosets widely out sell thermoplastics in the total market, but more structural thermoplastics are marking in roads in automotive for vehicle lightweighting,” says Marianne Morgan in new business development with BASF. In addition, as aerospace has adopted more thermoplastic composites in the last five years, their overall role within the industry has begun to change.

“The use of thermoplastics in aerospace] proves the technology to other industries,” explains Dwight Baker, vice president of advanced composites at Composites One. “At the same time, it increases the education of the engineers, so they are able to engineer them into other products.”

Today, reinforced thermoplastics have expanded into structural automotive parts, as well as oil and gas, electronics, infrastructure and marine applications.

Making a Case for Thermoplastics

Thermoplastic composites are used for applications that require high levels of rigidity (stiffness) and impact strength, as well as temperature, humidity and chemical resistance. “In many cases, thermoplastics are the best solution for applications requiring higher output production, lightweighting or fracture toughness,” says Baker.

In contrast to thermoset composites, thermoplastics have a one-step cure process that doesn’t require a catalyst, oven or autoclave. This fast-cure cycle is why thermoplastic composites are used in mass production methods, such as injection molding. Thermoplastic polymers aren’t chemically cross-linked after curing, which allows them to be remelted and reformed. This provides unique post-forming capabilities and solves the end-of-life cycle challenges associated with thermoset composites. In fact, many see their recyclability as key to future growth.

New reinforced thermoplastic radomes being built across the United States over the next three years, such as the one on the left, are expected to last 25 years without degradation.

Polystrand, which was acquired by PolyOne in 2016, began working with thermoplastic composites in 2001 because of their recyclability. “At the time, there was a lot of attention on recycling – and there still is,” says Mike Gordon, formerly with Polystrand and now president of Gordon Development. “Thermoset composites are very, very difficult to recycle. We saw the future as being able to make products with thermoplastic composites and use the manufacturing byproducts to make other products.”

Dana Swan, business development manager of the Elium® product line at Arkema agrees. She points to automobile standards in the European Union (EU) and Asia that require nearly fully recyclable vehicles. “Right now, it’s the EU. But I believe [similar standards] are coming to the U.S.,” she says. “There’s been great strides with thermosets’ recyclability, but in order to truly get a recyclable model, you have to go to thermoplastics.”

The Alfond Advanced Manufacturing Lab for Structural Thermoplastics at the University of Maine aims to increase the market presence of structural thermoplastic through development of innovative manufacturing processes to decrease cycle time, reduce waste and enhance repeatability and part quality. “It’s about making parts that are recyclable – just like aluminum and steel parts – but much, much lighter and highly engineered,” says David Erb, senior R&D program manager of the lab.

Five Key Trends

The evolution of thermoplastic materials and processes in the last decade has created more sophisticated non-structural parts for mass production, new advanced materials for high-performance applications and structural composites, and hybrid processes that utilize both. Here are five key developments in the ongoing evolution of thermoplastic composites.

1. Long Fiber Reinforced Thermoplastics

Most thermoplastic composite parts are made with noncontinuous fibers using injection molding. Short fibers (less than ½-inch) have been used in thermoplastic composites in the automotive sector for decades. More recently, long fiber reinforced thermoplastics (LFRTs) from ½-inch to one inch have entered the market. LFRTs are commonly available.
as pellets and used primarily in injection molding and compression molding.

Gordon says that long fibers enable more strength with less material. Aerospace manufacturers were early adopters of LFRT technology. LFRTs have begun to proliferate the automotive market not only for lightweighting advantages, but also because they are easy to process. “It’s a quick heat and cold cycle to mold something from LFRTs,” says Gordon. Long fiber injection molding also provides better creep impact and fatigue, says Morgan.

Direct long fiber thermoplastics (DLFTs) is a newer processing technique that provides long fibers without melting preformed pellets. In a three-step process, DLFT compounds a resin – typically polypropylene – with any additives, cuts continuous fiber rovings directly into the resin and then extrudes a portion of the reinforced material into a compression molding tool in the form of a dough-like charge or ‘bun.’ This allows control of the fiber length.

2. Continuous Fiber Reinforced Thermoplastics

Continuous fiber reinforced thermoplastics (CFRTs) are found in unidirectional tapes and used for woven sheets, filament winding and pultrusion. Ed Pilpel, senior technical advisor for PolyOne™ Advanced Composites, says that the introduction of CFRT prepreg materials has significantly improved the impact resistance of thermoplastic composites. This, in turn, has spurred new potential applications for materials such as Polystrand™ continuous fiber glass reinforced polypropylene in markets as varied as transportation, building and construction, and ballistic protection.

One application is truck liners. For years, truck liners were made with glass reinforced polyester thermosets, which were easily damaged. “The thermoplastics [liners] ended up being much more puncture proof. They would take the abuse more than the polyester thermal liners,” says Pilpel. “Most companies have switched over completely to thermoplastic [composites] now.”
3. Engineering Polymers
Morgan says the expansion of engineering resins – with long and short carbon fiber reinforced polyamides and high-performance polyphthalamides – are key drivers to the spread of thermoplastic composites. Unlike less expensive commodity resins, engineering polymers offer exceptional mechanical properties at elevated temperatures, increased stiffness and toughness, and low creep. This makes them ideal for more metal-to-plastic structural components opportunities.

For decades, Morgan says the automotive sector used “the pretty polymers” – acrylonitrile butadiene styrene and polycarbonate – to make aesthetic, interior composite parts, such as interior trim. Now, automakers are turning to polyphthalamide (PPA) thermoplastic and carbon fiber reinforced polyamide composites for more structural parts. For example, Ford uses Ultramid® short carbon fiber polyamide to manufacture a chassis part for the Shelby GT350 Mustang and has demonstrated advanced powertrain parts in long carbon fiber polyamide.

Morgan says PPAs are important because they enable the conversion from heavier steel parts to lighter composite parts that wasn’t previously possible. “Engineering plastics will play a big role in helping OEMs cost effectively meet emission and fuel efficiency standards,” she says.

Morgan adds that advanced thermoplastic polymer composites also enable many digital technologies, including advanced driver-assistance systems designed to automate and enhance vehicle systems for safer driving. PPAs are used to fabricate the many censors and electrical connections these systems require because they are small, thin and light and have high temperature tolerances that allow them to be safely packed together in small spaces.

4. Compression Molding
While not as widely used as injection molding – especially in the United States – compression molding can be a lower cost alternative. “It won’t be as fast as injection molding, but if you are making fewer parts, it’s a lot less costly to build the mold,” says Pilpel.

Compression molding can also produce higher fiber parts. Pilpel says the University of Alabama at Birmingham’s Materials Processing & Applications Development Center has used selective reinforced compression molding to achieve 65 to 70 percent fiber content – a marked contrast to injection-molded parts that typically yield 30 to 40 percent. Higher fiber content can help maximize properties, especially stiffness, for applications where that is important.

Numerous efforts to increase the speed of compression molding for structural parts are underway. The Alford Lab at the University of Maine is working with industry to demonstrate the efficacy of combining automatic tape laying (ATL) with compression molding. Erb says that the lab uses an ATL machine to rapidly lay down pre-consolidated structural tapes in various orientations before they are ultrasonically welded together and compression molded. The lab has used the process to develop a prototype of an automobile differential cover.

Meanwhile, an industry consortium based in France, the IRT-M2P, has developed an innovative processing method called Fast RTM. The resin transfer molding process enables two-minute cycle part production of structural thermoplastic and thermoset composite parts for the automobile and aerospace industries. Last year, consortium member Arkema introduced Elium, the first liquid thermoplastic that can be cured at room temperature. Like thermosets, it also cures in a two-step process that uses an initiator. The Fast RTM platform infuses CFRT with Elium and molds it in a Pinette P.E.I. short-stroke ECS-Press. Because Elium is a liquid reactive system and does not have to be heated to the same high temperatures as other thermoplastics, the process can be used to mold net shape CFRP thermoplastic parts.

5. Overmolding
Overmolding refers to hybrid processes in which two different
Overmolding can also be used with CFRT compression molding. For example, PolyOne’s Polystrand continuous fiber thermoplastic reinforcements are strategically placed into a tool and then compression overmolded with long fiber polypropylene in certain automotive applications. This provides reinforcement that keeps parts from unlatching upon impact. Pilpel believes that this kind of selective reinforcement, using overmolding, is an extremely important innovation. “This is clearly where the market is going,” he notes.

In a different type of overmolding, thermoplastic is injected onto the surface of basic compression molded parts. This allows materials to be molded together, with the base layer molded first and additional layers molded into, on or around the original part. In the most common type of overmolding, CFRT is placed into an injection molding tool and then short or long fiber thermoplastics are injected into the mold.

“We consider continuous fiber with a short fiber injection-molded material one of, if not the, most important advancement in thermoplastic composites,” says Baker. “It provides a lot of design flexibility.” For example, you can build in integral ribs and attachment points and reduce the weight and cost compared to a completely injection-molded part, he says.

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What's Ahead for Thermoplastics

Adoption of thermoplastic composites is growing. Erb says that as industry continues looking for ways to replace metals with lighter weight, structural composite parts, thermoplastic composites are gaining increased attention. The full-life analysis value of thermoplastic composites parts is simply better, he says. Not only can they lightweight vehicles and other applications, but because they are lighter and melt at lower temperatures, they use significantly less embodied energy in their processing, transport and recycling than metals. “Right now, there’s a huge trend in thermoplastic composites,” says Erb. “And there is a reason for that: It’s starting to be a value proposition that makes sense.”

Many companies are banking on it. PolyOne added continuous fiber thermoplastic composites to its portfolio with the purchase of Polystrand in 2016, and it acquired PlastiComp, a leading LFRT composite producer, in June. “Composites are a significant focus for us,” says Doug Hammond, technology leader at PolyOne. “We believe these materials will play a major role in key markets for plastics going forward.”

One of the primary challenges Hammond sees in the increasing use of CFRT materials is the ability to design products with high assurance that can be easily manufactured. “The data needed to reliably run FEA and process modeling software is lacking, so we are actively working to generate the information needed by the design community,” he says.

Large-scale industry will continue to demand automation in the future, and thermoplastic composites are innately suited to automated production. “[Automation] is obviously a big question mark with a lot of composites manufacturers now,” says Marcy Offner, director of communications and marketing at Composites One. “Where does it fit in, and how can they use products that automate their processes? Thermoplastics might eventually hold the key to that.”

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Join ACMA’s Thermoplastic Composites Working Group

The Thermoplastic Composites Working Group (TCWG) is one of ACMA’s Composites Growth Initiatives’ newest industry councils. The TCWG was formed to lead initiatives that foster growth of thermoplastic composites through education, market development and standards development. It is currently focused on education within the composites and plastics industry to showcase products, 3D printing and other advanced manufacturing processes for thermoplastic composites. For more information, contact John Busel at jbusel@acmanet.org.
For four decades, ACMA has been the voice, advocate and protector for the composites industry. In those 40 years there have been times of great political tension, and we certainly find ourselves in that environment again. However, with ACMA’s member and staff resources and support, we are poised to navigate the current political landscape with finesse and in a way that provides a positive outcome for the composites industry. In 2019, there are several key issues to solve that require ACMA and the industry to be a part of the conversation. ACMA brings solutions rather than problems, and we stand prepared to work with both political parties. Let’s explore these key issues further.

Infrastructure has been a focus for ACMA’s congressional advocacy program for the last few years and that will accelerate even more in 2019. After successfully working with leaders in Congress to introduce the IMAGINE Act – seminal legislation to drastically expand the use of innovative materials in American infrastructure – ACMA must aggressively generate support for the legislation so it can be integrated into a broader infrastructure stimulus package. To help us do this, we have two key tools at our disposal: a coalition of associations and companies from across the broader material industry committed to advancing IMAGINE and, most importantly, our dedicated members that consistently engage their congressional representatives in Washington on composites industry issues. The more members of Congress who co-sponsor any bill, the greater the likelihood of success. We have our marching orders to keep pushing this legislation and will do so at the Infrastructure Fly-In in February.

IMAGINE seeks to create a broader paradigm shift, moving away from traditional methods toward innovation and long-term thinking. This can change the outlook for composites, but other barriers remain in the market. One of those barriers is standards. The composites industry has invested significantly in standards development for years, but compared to traditional materials we are a long way off.

ACMA has the attention of the National Institute of Standards and Technology (NIST) and Congress on this issue. In 2018, ACMA members Shane Weyant of Creative Pultrusions and Hota GangaRao of West Virginia University testified on the value a composites program at NIST could bring to infrastructure resiliency and national competitiveness. Working with our allies in Congress, ACMA secured the introduction of legislation to provide $11 million for NIST to conduct research for composites standards development. In 2019, we need to get the legislation over the finish line and the program underway.

We are looking beyond infrastructure, too. ACMA’s Composites Growth Initiative has driven support for composites by large automotive and aerospace OEMs through our growing Composites Technology Day series. In the new Congress, we will continue to increase our firepower in this area to make sure composites are recognized as the go-to material for the future of mobility and national security.

ACMA’s environmental, health and safety advocacy in 2019 will focus on the regulation of health risks in composites industry workplaces, an ongoing concern for state and federal regulatory agencies and for organizations that promulgate voluntary
workplace standards. ACMA’s Regulatory Steering Committee (RSC) is concerned these organizations may fail to consider the full scientific database and the feasibility of control. According to RSC Chair David Ring, corporate manager of governmental affairs & strategic projects at Strongwell, “The RSC believes that the clarification of workplace risks related to styrene exposure is the most critical long-term regulatory issue facing the industry.”

Many composites industry companies are concerned about the impact of the 2019 edition of NFPA 400, the fire protection standard for storage of organic peroxides and other hazardous chemicals. The provisions for organic peroxide storage are undergoing numerous changes as a result of recent fire testing of commonly used formulations and adoption by NFPA of a new approach to fire protection for hazardous chemicals. ACMA is working with organic peroxide suppliers and NFPA to ensure the provisions of the code are based on an adequate understanding of the hazards of the material and allow workable storage methods.

This year, the RSC will provide additional content and activities for the ACMA Workplace Safety Program introduced in 2018. This voluntary program helps – and provides recognition to – composites manufacturers adopting OSHA’s recommended practices for workplace safety management programs. Companies adopting the practices benefit from reduced workplace safety incidents, reduced turnover and improved operating efficiency. Widespread participation in this program will also help ACMA show regulatory agencies that the composites industry does not need additional regulation.

ACMA expects resolution in 2019 of the Prop 65 enforcement actions pending against composites manufacturing operations in California. Legal notices filed by a public health advocacy group claim several ACMA members violated Prop 65 by failing to provide warnings before exposing community members to the styrene emitted from their manufacturing operations. The ACMA California Composites Council has retained legal counsel and is seeking clarification of state policy that manufacturing emissions are regulated via operating permits and not Prop 65.

On all of these issues, ACMA looks to industry leaders for guidance. We hope you’ll join us in these efforts and get involved however you can. If we work together, we can be successful. If we’re successful, America wins across the board.

MJ Carrabba and John Schweitzer lead legislative and regulatory affairs programs at ACMA. They can be reached at gov.affairs@acmanet.org.

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Get Involved, Be Heard

To be successful in our infrastructure policy efforts, the industry needs you to participate in ACMA Infrastructure Day, Feb. 13-14 in Washington, and tell your lawmakers that composites are the pathway for infrastructure renewal. For more information on Infrastructure Day, visit www.acmanet.org/infrastructure.
Pultruders to Gather in the Windy City

As a member of the North American Pultrusion Conference’s planning committee, Rick Pauer of Polynt Composites in Carpentersville, Ill., spoke with ACMA about the upcoming conference, which will be held April 8 – 10 at the Hyatt Rosemont in Rosemont, Ill. Pauer, who is an applications specialist with Polynt and treasurer of ACMA’s Pultrusion Industry Council (PIC), helped plan the inaugural North American Pultrusion Conference in 2017, which exceeded expectations. Organizers had to cut off registration at 150 attendees – twice the committee’s original goal. Building on that success, Pauer and his peers are looking forward to the 2019 North American Pultrusion Conference.

Q: What are you most excited about for the 2019 North American Pultrusion Conference?

Pauer: We have been able to develop a better, more focused program that falls into six topical categories: design and simulation, research, manufacturing, standards development, testing and tooling. In 2017, our keynote speaker, Jeff Martin of Martin Pultrusion Group Inc., focused on where the pultrusion industry originated and who some of our key industry leaders were throughout our history. This year, our keynote address will focus on our industry from a customer’s application perspective.

Q: What new processes or products do you expect to see at this year’s event?

Pauer: I am very excited to hear Steve Gonzalez of Kone Elevator describe his company’s pultruded Ultra Rope® materials that take advantage of several key benefits of carbon fiber over steel cables – significantly lighter weight, higher strength and much improved fatigue properties (steel stretches). There also will be lots of interesting presentations on a variety of topics, such as a new, hardened nano-coating from Phygen Coatings Inc. that might replace chromed tooling and curved pultrusion for automotive applications from Shape Corp.

Q: With the participation of the European Pultrusion Technology Association (EPTA), what perspectives can attendees expect to gain?

Pauer: In 2017, we had an outstanding presentation from Dr. Klaus Jansen (Thomas GmbH + Co. Technik + Innovation KG) that introduced North American pultruders to his company’s unique process for making curved pultruded profiles. This year, we will have two presentations from EPTA members. One will address efforts at getting composite materials approved by the Eurocode (CEN TC250), and the other will be from the Fraunhofer Research Institution for Casting, Composite and Processing Technologies on European pultrusion industry trends and research. To grow the pultrusion industry in North America, it’s important that we understand what’s happening in the field throughout the world.

Q: What are some of the challenges with the pultrusion process that need to be addressed?

Pauer: I’d say our biggest challenge is the code approvals that the PIC is attempting to support with our Load Factored Resistance Design efforts. We will have updated information available to the PIC at our meeting in April in conjunction with the Pultrusion Conference.

Another area that needs attention is education of the engineering and architectural communities. We have begun providing education at venues such as the International Bridge Conference, where ACMA has participated for the last 18 years; the American Institute of Architects Conference, where we have participated for the last 4 years; and with the American Concrete Institute’s 440 Committee on FRP Reinforcements, which has done much of the heavy lifting for reinforcing concrete over the last 25-plus years.

Getting our members – especially our pultruders – in front of state and federal legislators can also be very helpful as some of our politicians are finally beginning to understand that low bid is not necessarily the best bid! Pultruded products generally cost more than traditional materials but offer many long-lasting benefits in corrosion, weight, parts consolidation and strength.

Q: What do you hope professionals will gain from attending the conference?

Pauer: There are two huge benefits. First and foremost is education on what is happening in the pultrusion industry. The second benefit is the opportunity to network with others who have similar interests in the FRP composites area, especially in the pultrusion process. This industry is expanding so rapidly that
it really is necessary to continue education and networking on a regular basis.


TSC Planning Workshop at IBC

In December, the Transportation Structures Council submitted another technical workshop for the International Bridge Conference, June 9-13, 2019, in National Harbor, Md. (Washington, D.C.). The proposed slate of presentations will focus on technology advancements, standards development and case histories of products used in bridge construction. If accepted, this would mark the 19th consecutive technology workshop organized by TSC at this international bridge event. For more information, contact John Busel at cgi@acmanet.org.

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For more information on becoming a member of ACMA, email membership@acmanet.org or call 703-525-0511.

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ACMA Composites Tech Days

ACMA’s Composites Technology Days have been in demand from both the composites industry and OEMs. They continue to be a unique member benefit for both new and existing ACMA members. The members-only Tech Day events provide ACMA member companies the ability to showcase their products and give OEMs the opportunity to foster a deeper connection with the design community and supply chain. Composites Tech Days are currently being planned for the automotive, aerospace and industrial markets. Need more information about upcoming Tech Days and how your company can get involved? Contact Scott Lindley, ACMA’s vice president of membership and strategic partnerships, at slindley@acmanet.org to join a Composites Growth Initiative committee or learn more about these exclusive member benefits.

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