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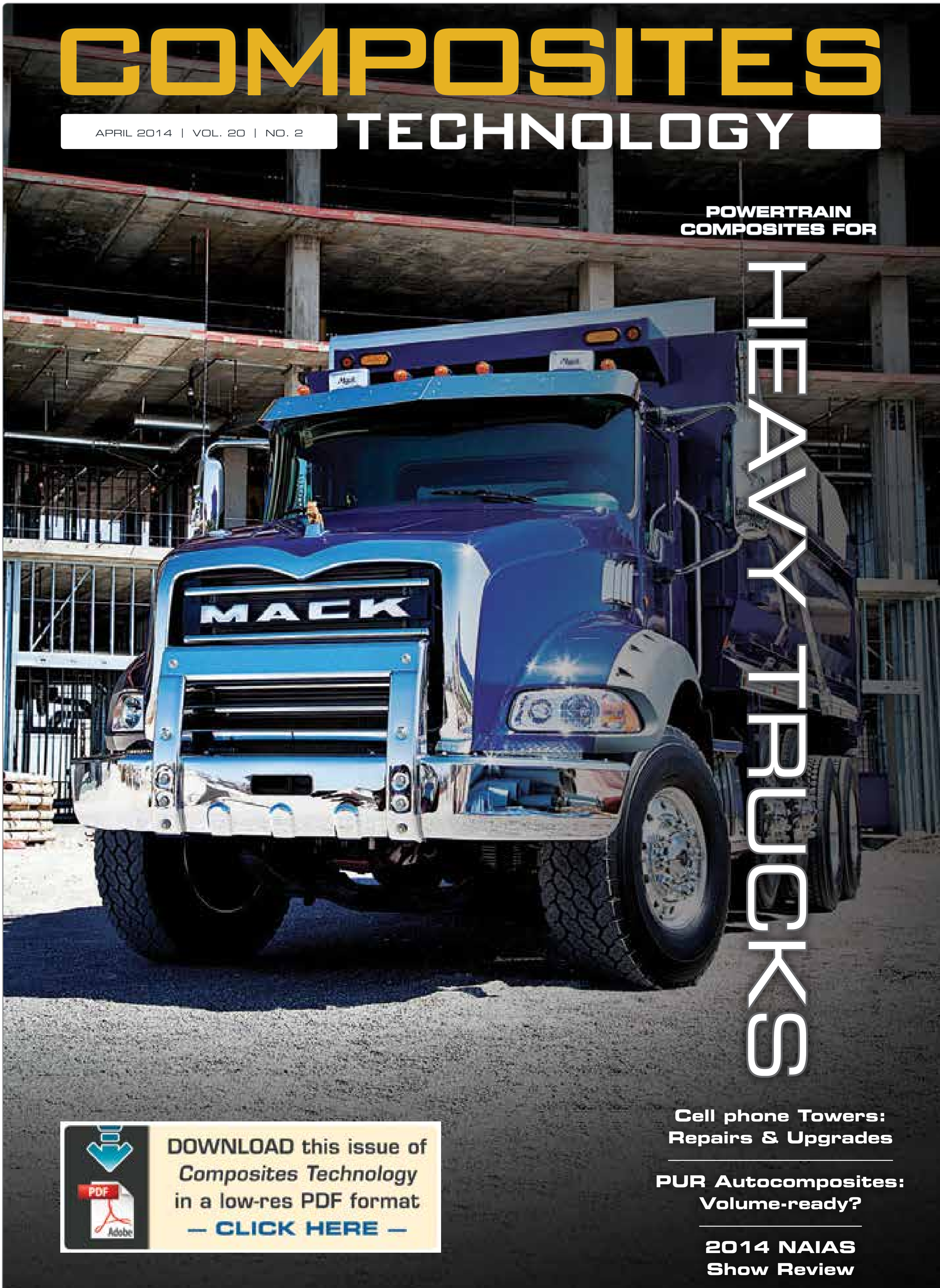

COMPOSITES TECHNOLOGY

APRIL 2014 | VOL. 20 | NO. 2

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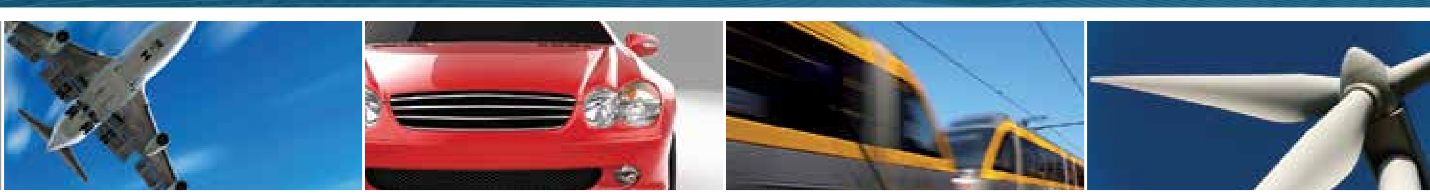

COMPOSITES TECHNOLOGY

April 2014 | Vol. 20 | No. 2

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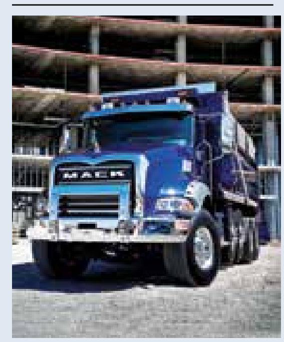
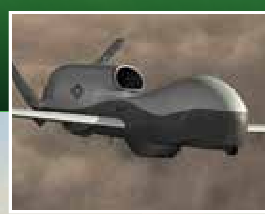


A thermoplastic composite has replaced cast aluminum in the transaxle inspection cover assembly on drive axles produced by American Axle Manufacturing Inc. (Detroit, Mich.) for tandem-axle trucks like this one, built by Mack Trucks Inc. (Greensboro, N.C.). The two-piece assembly is molded by Sturgis Molded Products (Sturgis, Mich.). For the story behind the innovation, see p. 24.
Source | Mack Trucks



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Business & Busy-ness

We just got back from JEC Europe 2014 (March 11-13, Paris, France). We look forward to this show because it affords us a look, all at once, at what many of the industry's most important suppliers have in store for you in terms of product and technology development. We came away feeling as if we'd just drunk from a fire hose, overwhelmed by innovations numerous enough to keep the composites industry busy for a quite a while. Although we plan a full JEC report in the June issue of *CT*, it's worth noting here a few of the most intriguing trends we observed. (For a hint of the new technology we saw, see "New Products" on p. 42.)

System integration: The automotive industry is demanding of composites fabricators the same consistency, repeatability and quality that they are used to getting from legacy materials and processes. Touch labor is out. Automation is in. Several suppliers, including Pinette Emidecau, Dieffenbacher, KraussMaffei, Fives Cincinnati, Engel and RocTool, introduced or emphasized turnkey manufacturing cells for resin transfer molding (RTM) or compression molding. Each promised lots of automation, short cycle times, consistency and applicability to high-volume environments.

Snap-cure: A molding system is only as fast as its resin, and materials suppliers are getting that message. Dow introduced an epoxy with a <*90-second* cycle time, targeted specifically to the automotive market. Henkel, Momentive, Cytec, Huntsman, Gurit and Bayer are all in the same cycle-time neighborhood with thermoset materials of their own, for RTM, pultrusion, infusion and compression molding processes.

> The composites industry is in the midst of dynamic expansion.

Thermoplastic-friendly carbon fiber: Because carbon fiber is seeing increasing use in automotive applications and thermoplastic composites are seeing increasing use everywhere, making the two compatible has become a necessity. SGL Group and Toho Tenax each introduced at JEC Europe a new carbon fiber sizing optimized for thermoplastic resins.

Passenger tubs: Composites fabricators seem to have determined collectively that the best way to alert automakers to their proficiencies was to mint a carbon fiber composite passenger protection cell, either for a real car (high-end sports) or as a capability demonstrator. *CT* counted no fewer than 10 tubs on display.

The *other* tub: Among the JEC Innovation Award winners, what most caught our eye was the glass fiber-reinforced polypropylene washing machine tub molded by Russian firm Polyplastic, using Owens Corning materials. Hydrolysis-resistant, the tub enables an increase in laundry load from 5 kg to 7 kg (11 lb to 15.4 lb).

Styrene-free: Reichhold, it appears, has cracked the styrene-replacement code for vinyl ester, introducing at JEC a new product called ADVALITE. Technically a vinyl "hybrid," it offers no-VOC performance without the use of reactive diluents (see p. 34 for more news about styrene *and* cobalt replacment technologies).

If the activity level, crowds and busy-ness of JEC Europe 2014 are an auger of overall industry health, then it's probably fair to say that the composites community is in the midst of significant and dynamic expansion. We certainly hope so.

Jeff Sloan

Why are suppliers morphing into fabricators?

Bio | Mike Musselman

A journalist with 20 years of technical trade magazine experience, Mike Musselman is in his 13th year as the managing editor of *CT* and sister publication *High-Performance Composites* for CompositesWorld. Based in Denver, Colo., he coordinates the efforts of a team of inhouse and freelance editors and writers and steers each issue's editorial content through the production process.

As *CT*'s managing editor, I have the luxury of a bird's-eye view of the industry. From that vantage point, I sometimes see trends and wonder if those "in the trenches" miss them, by virtue of their focus on the job at hand. A recent article written by *CT* senior editor Ginger Gardiner, titled "The structural grid: Prefabrication," put into sharp relief one such trend. It tells the developing story of distributors to the boatbuilding industry who are making a transition from cutting and kitting of core materials and fabrics to construction of significant portions of internal boat structures (see *CT* February 2013 (p. 30) or visit short.compositesworld.com/vQlFO7Xp).

When the *CT* staff recently gathered for its annual look at stories on the horizon, *prefabrication* opened our eyes to the growing number of materials suppliers and distributors that are becoming manufacturers, electing, at least to a degree, to *compete with their customers*. This week alone, I received several press announcements on this theme: Among them, Arkema, a well-known supplier of additives and cure initiators to this industry's formulators/suppliers premiered its *first complete resin system* — a *liquid* thermoplastic, no less, that can be processed like a thermoset. And Compose, a respected toolmaker that serves composites fabricators in Bellignat, France, trumpeted the opening of a subsidiary that will mold finished composite parts. I could go on.

Notably, tooling specialists were among the earliest prefabricators. Taking on the increasingly demanding and critical task of toolmaking as specialists, they freed molders for other tasks. Indeed, toolmakers today find that to get contracts, they often have to provide additional services, such as minting prototype or preproduction parts, to prove their tool to the customer.

Today, the trend is very broad. DIAB (DeSoto, Texas), for example, created the Composites Consulting Group to assist its customers with software-based product design and simulation (virtual testing).

"I believe that most of these new developments come out of necessity," contends infusion specialist Andre Cocquyt (ACSM Inc., Brunswick, Maine). "If the vendors would be able to sell their materials in volume, and with a decent margin, to fabricators, they would most likely *not* compete." Cocquyt has been there: As a distributor in the early 1980s, he says, "The problem was that all our profits went up into dealing with troubleshooting — training our clients in proper use of our products. And fairly often, despite significant marketing efforts, we were not able to convince conservative fabricators of the benefits of our (back then very new to the market) high-tech products and the markets these innovative products could open for them. The result: within three years we opened our own prototyping and small production shop, where we built everything from round-the-world racing sailboats to passenger train interior panels. And yes, the same companies that wouldn't give us the time of day were the first ones crying foul that we were unfairly competing!"

One materials supplier notes anonymously that the trend has accelerated since the Great Recession. "The composites, and with it the material markets, worldwide, are under significant overcapacity and cost pressure," he notes. "With the meltdown both of volumes and prices, companies were forced to rethink their business model. This has motivated several companies to venture into additional offerings: parts production, tool production/services, etc."

Suppliers and distributors to the composites industry, then, have felt compelled to take matters into their own hands to secure their product pipeline. Today, they feel obligated to assist customers in the proper use and processing of new and often finely tuned materials. The market for their products *depends on technology validation*. Therefore, says *CT* columnist, consultant and president of Quickstep Composites (Dayton, Ohio) Dale Brosius, suppliers are often directly involved in end-product development. "A lot of the specification work in aerospace, automotive, boatbuilding and corrosion-resistant markets are done by suppliers of resins or prepregs directly to the OEMs or end-users" he points out. "Composite fabricators/molders sit in the middle of this equation but typically do not invest significantly in market development." That puts molders at risk of removal from the equation if, says Brosius, "the application requires a new process or is innovative enough there is no one with the capability to do it and the suppler sees an opportunity to capture that value."

Supplier/distributor Gurit (Isle of Wight, U.K.) has done just that through subsidiary Gurit Automotive Ltd., which builds Class A composite parts directly for auto OEMs. Just this week, it reported that it has secured an exclusive contract with an auto OEM.

The auto industry, now seen (again) as a huge and promising market for composites, could be the trend's most important bellwether because, says one supplier, *market maturation* is a key factor. As OEMs grow and proliferate, he contends, they tend to outsource more functions. This invites subpart prefabrication, which is relatively new in the boatbuilding industry but is standard practice in the auto industry, with its proliferation of tier supply networks.

Indeed, to secure a place in the still prospective market for carbon fiber composites in production autos, no less than Toray Industries (Tokyo, Japan) has not only bought out St. Louis-based heavy-tow carbon fiber source Zoltek Corp., but also acquired a 20 percent interest in Plasan Carbon Composites (Walker, Mich.), a high-profile fabricator of Class A carbon fiber auto body parts.

Here, however, Brosius offers some perspective: "Downstream integration in the composites industry by material suppliers is not a new thing," he notes. "It has been going on for *decades*." And, he adds, the result is "sometimes positive, and sometimes not." Shell Chemical, for example — a supplier of epoxy resins that are now part of the Momentive Specialty Chemicals (Columbus, N.Y.) portfolio — set up a design and prototype capability for automotive structures in the Detroit area in the early 1980s, he recalls. "Then they acquired a majority stake in an Ohio SMC molder, and full ownership of Ardyne, a Grand Haven, Mich., molder of parts via structural resin injection molding (SRIM). Within five years, they exited both businesses."

This cautionary tale underscores the fact that, especially in the auto industry, the risks are great and the stakes are high: A supplier's resin, fiber or core product can be processed to automotive standards only if they are processed by methods and under conditions that the suppliers have discovered through hard effort and at great expense. The simplest, most straightforward way to ensure that demand continues is to control the process and make the parts yourself. No surprise, then that an SGL (Wiesbaden, Germany) might want to jointly *build a carbon fiber factory* and *fabric manufacturing facilities* with a BMW AG (Munich, Germany) to ensure demand for its product.

That, of course, begs the question, *Where does that leave that supplier's* customers*, who would also like to market composite parts to that same OEM?* At a potential competitive disadvantage, answers one experienced salesperson, who proceeds very carefully when collaborating with a materials supplier that also makes parts. His company, he says, has two fears: "One, that the Structures Division of the materials supplier, as a result of his meetings with them, would hear about an opportunity through its Materials Division, and, two, that the Structures Division could buy material *cheaper* than we could, if we were competing for the same job." Structures companies often work with materials suppliers during the bid process, he explains. "And in that bidding process, the supplier's parts makers would have the obvious edge."

Not surprisingly, materials suppliers and distributors tend to see the upside of this trend. "Generally, I find these trends positive," says one core supplier. "It will make our industry more competitive and more professional, accelerate innovation and necessary structural changes, and force each party to maximize their share of the value creation in the value chain."

But what do *you* say? *CT* wants to know. I'll entertain your comments via e-mail, at mike@compositesworld.com (please label your e-mail in the subject line with "Why are suppliers morphing into fabricators?"). To measure the industry's pulse on this subject, we're also sending a survey to key people at companies throughout the composites industry. We'll send the survey questionnaire via e-mail on or about April 8, 2014 and we'll publish the results in this space, in our June issue. | CT |

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PRESENTER

Doug Kenik
Product Manager
Design, Lifecycle
and Simulation

Simulating ultimate failure: Converging on a solution with composite materials

EVENT DESCRIPTION:

In this Webinar, Doug Kenik will discuss the need for simulating past first ply failure in conventional implicit FEA tools and how to achieve convergence using Autodesk Simulation Composite Analysis. Simulating ultimate failure in composite structures using traditional implicit FEA codes can be very challenging. The behaviors of composite materials are inherently nonlinear during failure cascades, and FEA solvers can have difficulty converging on solutions during such events. Join us as we discuss simulating ultimate failure, and coupling inter and intra-laminar failure using Autodesk Simulation Composite Analysis coupled with Abaqus, ANSYS, and MSC Nastran to achieve convergence.

PARTICIPANTS WILL LEARN:

- Understanding composite behavior during failure
- How to leverage Abaqus, ANSYS, and MSC Nastran with Autodesk Simulation Composite Analysis

PRESENTER'S BIO:

Doug Kenik is a Product Line Manager for composite simulation products within Autodesk. He holds both an MS and BS in Mechanical Engineering from the University of Wyoming where he spent his graduate career developing high fidelity micromechanics models for composite material simulation. Prior to working at Autodesk, Doug spent 5 years as a developer and Application Engineer at Firehole Composites, where he helped implement new technologies for composite simulation and define next generation enhancements for use within existing products.

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MOVE OVER, STEEL — ALUMINUM IS NOW THE TARGET

Bio | Dale Brosius

Dale Brosius is the head of his own consulting company and the president of Dayton, Ohio-based Quickstep Composites, the U.S. subsidiary of Australia-based Quickstep Technologies (Bankstown Airport, New South Wales), which develops out-of-autoclave curing processes for advanced composites. His career includes a number of positions at Dow Chemical, Fiberite and Cytec, and for three years he served as the general chair of SPE's annual Automotive Composites Conference and Exhibition (ACCE). Brosius has a BS in chemical engineering from Texas A&M University and an MBA. Since 2000, he has been a contributing writer for *Composites Technology* and sister magazine *High-Performance Composites.*

It's been a year since I started this column, in which CompositesWorld gives me free rein to express what's on my mind. Inspiration comes from a lot of sources, one of which is feedback from readers via e-mail (daleb@compositesworld.com). My first reaction was, "Hey, someone is actually reading these columns!" Some correspondence is from past or long-time industry acquaintances who simply want to say "hello" or make a general comment on the content. And I received one from a young engineer at a U.S. OEM, who wanted to meet and gain more insight into carbon fiber (I was flattered and happy to oblige).

> Chasing aluminum as a competitor is a much easier task than chasing steel — *if* the composites industry can meet cost and volume requirements.

But I especially appreciate those responses that extend my narrative, citing other examples or angles I might not have considered. Some are contrarian, taking an opposing position, which I also welcome. I do my best to respond and establish a dialogue; it helps me develop my own perspective on the industry.

Recently, I received an e-mail from a former plastics and composites engineer who had worked at GM and Chrysler over the course of several decades. He responded to my February 2014 column (short.compositesworld.com/GomKwRky) in which I lamented the nonproliferation of award-winning composites applications in vehicles, such as pickup boxes. He told me he had developed a composite pickup box for Chrysler that was displayed at the 2001 Detroit auto show, but the design never made it into production.

The Chrysler box was developed in response to those previously introduced by Ford and GM. (Both of these are, unfortunately, no longer in production.) The e-mail's author, in fact, told me that he has one of the box prototypes sitting in his backyard in Ohio, where it will never rust away like the steel box it was intended to replace. During the course of our e-mail exchange, he expressed his frustration with having been one of a few "composites guys" in a place populated with "metal benders."

A few days later, I was in a meeting with a major North American Tier 1 supplier of composite parts to the automotive and heavy-truck industries. One of the participants from the Tier 1 is the VP of advanced R&D. I've known him since the mid-1980s, when I was selling him Dow Chemical Co.'s (Midland, Mich.) vinyl ester resins to make high-performance SMC for structural parts. The discussion topic for this meeting was new materials and processes for making lighter weight composite parts. Options included low-density Class "A" SMC, carbon fiber SMC and high-speed resin transfer molding (HP-RTM), amongst others.

About 20 minutes into the meeting, I made the observation to the group that the word "aluminum" had come up in the discussion at least 15 to 20 times, but not once had the word "steel" been used! All of the composite technologies they were discussing are targeted to be both weight- and cost-competitive with aluminum. The meeting highlighted the fact that the goal, today, is not to be cheaper than steel (which is unrealistic for composites in high volumes), but to be cheaper than stamped aluminum.

Although aluminum body panels have been used on low- to medium-volume vehicles for more than a decade, the high-volume arena has been overwhelmingly dominated by steel. But this paradigm is set to change with the introduction of Ford Motor Co.'s (Dearborn, Mich.) aluminum-intensive 2015 *F-150* pickup, which was released to the public at this year's North American International Auto Show (NAIAS 2014) in Detroit, Mich.

The *F-150* is not only a vehicle known for durability, it is also Ford's largest selling model in North America — more than 750,000 units in 2013. By using aluminum in the body and structure, Ford claims a weight reduction that exceeds 700 lb/318 kg — clearly a response to forthcoming fuel economy requirements.

In mid-February, it was reported that General Motors Co. (Detroit, Mich.) had followed Ford's lead and signed major contracts with aluminum sheet suppliers to convert its line of pickups from steel to aluminum in 2018. Clearly, the landscape is changing.

In 1995, Chrysler chief engineer Francois Castaing notably commented, "Steel is for cars, aluminum is for airplanes, and plastics are for toys." At the time, composites content on commercial aircraft was less than 10 percent of structural weight, and it would be nearly 15 years before the composites-intensive Boeing 787 *Dreamliner* made its maiden flight, which will be followed to market soon by the Airbus A350.

Yes, the Ford and GM shift to aluminum for high-volume trucks is much easier to do in an environment full of "metal benders," but the trend is clear: the need for lightweighting is creating opportunities for materials substitution. For composites, chasing aluminum as a competitor is a much easier task, *if* the composites industry can meet the automotive OEMs' cost and volume requirements. I am sure of one thing: I wouldn't want to be in the steel business right now.... | CT |

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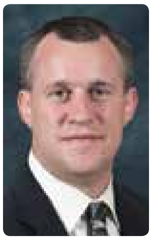
Composites Business Index 53.1: Growth in Four Out of Five Months



Bio | Steve Kline

Steve Kline is the director of market intelligence for Gardner Business Media Inc. (Cincinnati, Ohio), the parent company and publisher of *High-Performance Composites* magazine. He started as a writing editor for another of the company's magazines before moving into his current role. Kline holds a BS in civil engineering from Vanderbilt University and an MBA from the University of Cincinnati.

As the New Year turned, January's Composites Business Index of 54.1 was 8.6 percent higher than it was in January 2013, and showed U.S. growth at its fastest rate since May 2012.

New orders had reached their highest level since February 2012. After two months of moderate contraction, production grew at its fastest rate since April 2012. Backlogs grew for the first time since May 2012, indicating that the industry should see better capacity utilization in 2014. Employment grew, as it had done at a steadily increasing rate since June 2013. Exports, however, remained mired in contraction. Supplier deliveries continued to lengthen, and at a slightly faster rate than in the second half of 2013.

THE COMPOSITES BUSINESS INDEX

Subindices	February	January	Change	Direction	Rate	Trend
New Orders	57.0	61.1	-4.1	Growing	Slower	3
Production	58.5	59.6	-1.1	Growing	Slower	2
Backlog	51.5	50.3	1.2	Growing	Faster	2
Employment	51.5	53.3	-1.8	Growing	Slower	12
Exports	47.3	46.2	1.1	Contracting	Slower	22
Supplier Deliveries	52.6	53.9	-1.3	Lengthening	Less	27
Material Prices	68.4	64.5	3.9	Increasing	More	27
Prices Received	52.2	54.0	-1.8	Increasing	Less	3
Future Business Expectations	79.0	77.8	1.2	Improving	More	27
Composites Business Index	53.1	54.1	-1.0	Growing	Slower	3

Material prices grew at a faster rate in January, continuing a trend begun in August 2013. Prices received grew at its fastest rate since January 2013. However, the rate of increase was much slower than that for material prices. Future business expectations soared to its second highest level since the CBI began in December 2011.

Fabricators of all sizes grew in January. Those with 50+ employees continued strong, but the improvement was driven by smaller facilities: Those with 20 to 49 employees expanded at their fastest rate since June 2012, and those with fewer than 20 employees grew for the first time since March 2013.

Regionally, New England grew fastest in January, followed by the West North Central, which grew for the first time since July 2013. The Middle Atlantic expanded after two months of contraction. The East North Central grew for the third time in four months. The Pacific region expanded for the fourth straight month. The Middle Atlantic and South Atlantic, however, continued to contract.

Future capital spending plans were 17.8 percent higher than they were a year earlier. It was the fifth straight month that they were up from the previous year.

In February, the CBI of 53.1 showed that the industry had grown for the fourth time in five months — and had done so at its second fastest rate since May 2012. In fact, it had been improving at a generally accelerating rate since July 2013. The CBI was 6.2 percent higher than it had been one year earlier. It was the sixth straight month that the CBI had been higher than it had been in the same month a year earlier.

New orders grew in December 2013 and in January and February 2014, reaching their second highest level since February 2012. Production expanded at a significant rate in January and February, reaching its second fastest growth rate since April 2012. Backlogs increased in February for the first time since spring 2012, pointing to greater capacity utilization and capital investment in 2014. Employment continued to grow in February but did so at its slowest rate since September 2013. Exports were still mired in contraction at a rate similar to that in 2013. Supplier deliveries continued to lengthen but at a slightly slower rate than in the previous two months, but slightly faster than in the second half of 2013.

Material prices increased at a rapidly accelerating rate the first two months of 2014, and at its third fastest rate in CBI history. Prices received, rising in six of the past seven months, grew at one of its fastest rates since January 2013, but increased much more slowly than material prices. Future business expectations soared, reaching their second highest level since the CBI began.

Facilities of all sizes grew again in February. The rate of expansion, however, was significantly greater for facilities with more than 20 employees. Those with 19 or fewer recorded very slight growth.

Six of the seven U.S. regions registered expansion in February. The Pacific region grew the most, followed by New England, the South Atlantic, West North Central, Mountain, and East North Central. After expanding in January, the Middle Atlantic was flat.

Future capital spending plans were 30.2 percent lower than they were a year ago. It was the first time in five months that the month-over-month rate of change contracted. Change was likely, however, in March 2014 because the March 2013 CBI was one of the lowest yet recorded. Although the annual rate of change was still growing, the rate had slowed noticeably. | CT |

Composites WATCH

Feb. 17 is a big day for carbon fiber news in the U.S., and CompositesWorld preps for its Thermoplastic Composites Conference for Automotive in June.

AUTOMOTIVE

BMW/SGL to double Moses Lake production of AUTOMOTIVE carbon fiber

SGL Automotive Carbon Fibers (ACF) reportedly has started building a second production hall at its carbon fiber plant in Moses Lake, Wash. SGL ACF is jointly operated by BMW AG (Munich, Germany) and SGL Group (Wiesbaden, Germany) to meet BMW's rising demand for automotive carbon fiber. German newspaper *Handelsblatt* and *Bloomberg Businessweek* reported the news Feb. 17, citing unidentified sources close to the company. BMW and SGL were said to be investing more than €100 million ($137 million USD) to double carbon fiber production at Moses Lake to 6,000 tons a year. News reports claimed that BMW's chief financial officer Friedrich Eichiner said in October 2013 that the company is considering a production increase for its all-electric *i3* commuter car after early demand for the model exceeded the automaker's expectations. BMW has received 11,000 orders for the compact city car, which will retail for $41,350 in the U.S., and expects to sell more than 10,000 *i3s* this year. BMW's *i8* hybrid electric sports car also will be available this year. Both vehicles have a carbon fiber chassis, or "Life Module" passenger cell, to cut weight and improve fuel efficiency. Speculation in the automotive blogosphere was that BMW was variously experiencing difficulty keeping up with current production on its *i3* program and/or intended to expand its carbon fiber parts production beyond its *i3* and *i8* and more established *M* performance cars, according to a statement attributed to BMW spokesman Mathias Schmidt. Further, Eichiner was reported to have said that confidence in automotive carbon fiber is growing, and that composites will be used across the BMW model range.

Source | BMW

ENERGY

Flax fibers reinforce composite blades on rooftop WIND TURBINE

A rooftop wind turbine at the University of Stuttgart (Stuttgart, Germany) has been equipped with natural fiber-reinforced blades, made with Biotex Flax fibers supplied by Composites Evolution (Chesterfield, U.K.). Designed and manufactured by a team formed by the SWE (Endowed Chair of Wind Energy) at the University, the blades were conceived in 2011, to replace the blades on the school's existing 1-kW rooftop turbine. Reportedly, the SWE team found that the Biotex Flax reinforcement's "twistless technology" results in a high degree of fiber alignment and, thus (based on tests against other materials in a variety of matrices), yielded the desired performance characteristics. The finished blades incorporate Biotex Flax 2x2 twill (400 g/m^2) in the outer half shell with Biotex Flax unidirectional (275 g/m^2) used in the blade's spar and root. Shells, spar and root were hand-layed. Shells were vacuum-bagged and cored in separate female molds, then joined using RIM 235 epoxy adhesive, supplied by Momentive Specialty Chemicals (Columbus, N.Y.).

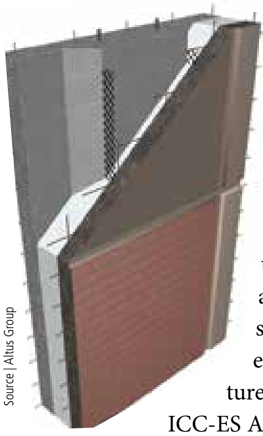
Three blades were performance tested on the rooftop turbine, and further testing will gauge their performance against blades of other materials. A fourth blade was embedded with strain gauges, and the team will compare the results to data derived from tests on standard carbon and glass blades. A finished blade was on display on the Composites Evolution stand at the JEC Europe 2014 trade show.

Standard Biotex reinforcements also include jute, commingled flax/polylactic acid (PLA) and commingled flax/polypropylene (PP). Other forms are available on request, in formats that include yarns, fabrics (woven and noncrimp) and preconsolidated sheets.

CONSTRUCTION

ICC-ES says carbon fiber grid-reinforced WALL PANELS meet code

CarbonCast high performance insulated wall panels, manufactured by the Bethlehem, Pa.-based Altus Group — 16 North American and three international concrete precasters — have been certified "code compliant" by ICC Evaluation Service (ICC-ES, Whittier, Calif.). CarbonCast panels feature innovative carbon fiber composite C-GRID shear truss connectors and rigid foam insulation. C-GRID is the enabling technology in CarbonCast that connects the panel's inner and outer *wythes* (vertical sections of concrete; see illustration). The high-strength carbon fiber grid's relatively low thermal conductivity results in negligible thermal transfer through the panel. As a result, the panels meet ASHRAE 90.1 standards and can significantly reduce energy consumed to heat or cool a structure. Panels were tested in accordance with ICC-ES Acceptance Criteria AC-422, published by the International Code Council (ICC, Washington D.C.). The ICC-ES report, ESR#2953, was published in February 2014.



Source | Altus Group

Building officials, architects, contractors, specifiers and designers reportedly use ICC-ES Evaluation Reports as a basis for using or approving products in construction projects under various ICC building codes. Further, many municipalities and building jurisdictions require ICC-ESR certification before allowing use of a structural building product in their area. "Altus Group precast manufacturers can now reference the evaluation report to assure building officials and the building industry that the product meets I-Code requirements," comments ICC-ES president Shahin Moinian. "Building departments have a long history of using evaluation reports, and ICC-ES operates as a technical resource with the highest quality of product review for the building department," he explains, but points out that "final approval of building products is always in the hands of the local regulatory agency."

ICC-ES reportedly examined Altus Group's product information, test reports, calculations, and quality control methods thoroughly. Testing for much of the ICC-ES criteria was completed in the accredited Constructed Facilities Laboratory of North Carolina State University (Raleigh, N.C.) and the test results were examined alongside data from prior research and testing done at other independent laboratories and agencies.

Source | Altus Group

John Carson, executive director of Altus Group, says the report capped two years of testing and close cooperation with the ICC. "We are confident that this report represents the most significant body of test work for shear flow and insulated sandwich panels and insulation systems to date," he says.

Jason Lien, the VP of design for EnCon United (Denver, Colo.), who coordinated the submission effort for Altus Group's Technical Committee, adds, "The report should put to rest any and all performance questions concerning the CarbonCast technology using expanded polystyrene (EPS) insulation and carbon fiber grid shear trusses."

Altus Group precasters have installed more than 28 million ft^2 (2.6 million m^2) of CarbonCast wall and deck area on more than 700 structures since the technology's introduction in 2004.

RECREATION

Infused LONGBOARD shows toughness of composite design

Skateboarding is a form of recreation and, for some, the vehicle for an extreme sport. But for many, it has also become, like the bicycle, an inexpensive and pollution-free mode of alternative transportation. With that in mind, the longboard was created and has exploded in popularity. As its name implies, this longer variant of the conventional skateboard, typically made from plywood or fiberglass, allows for a more stable and comfortable rider stance when cruising city streets. To ensure a long-lasting ride, however, N2R Skate (Turin, Italy) has introduced what it describes as a practically indestructible version that features an infused cored laminate. N2R opted to make its new product using a new material and a proprietary vacuum infusion technology, which it calls INFUTURE. An established method, INFUTURE has been used by N2R for 15 years to mold a wide range of products, ranging from large boat hulls to smaller go-kart racing components.

In collaboration with core manufacturer DIAB International AB (Laholm, Sweden), N2R developed a material it calls tricomposite, formed with a lightweight hybrid multiaxial from Formax (Leicester, U.K.) that combines carbon, aramid and glass fibers, and a DIAB Divinycell high-strength, closed-cell foam core. After infusion, the longboard is almost optically clear, and reveals the triaxial fiber weave as well as the core insert.


Source: N2R

N2R says that the new board offers 40 percent higher torsional strength compared to standard fiberglass models, and is 70 percent stronger than plywood constructions. The company is so confident of the longboard's performance that it is offering an unheard-of three-year warranty against structural damage. N2R Skate's longboards are reportedly 25 percent lighter than competing boards, completely water resistant and shock resistant.

"We have worked with DIAB for the last 15 years, producing some of the best yachts in the world," says Luca Sburlati, CEO of N2R. "Now it's time for us to revolutionize the skating business. We wanted to develop the next generation of longboards with outstanding flexibility and a much higher fatigue resistance, and we are glad to have DIAB as our partner on this quest."

N2R Skate is offering two different longboard configurations, the 1.6 kg *Urban*, designed to be fairly flexible, and the 1.98 kg *Downhill* with "race-ready" stiffness and strength, in an array of "wild" colors. Both were introduced in February through a Kickstarter campaign, with reduced pricing.

Composites NEWS

Mark your calendars: CompositesWorld's June 2014 thermoplastic autocomposites conference


Source | SCS

CompositesWorld, publisher of *High-Performance Composites* and *Composites Technology* magazines and the *CompositesWorld Weekly* e-newsletter, has banded together with parent company Gardner Business Media (GBM, Cincinnati, Ohio) and sister publication *Plastics Technology* to produce a new conference: Thermoplastic Composites Conference for Automotive. Colocated with GBM's ameri*mold* trade show for moldmakers, it takes place June 11-12, 2014, at the Suburban Collection Showcase in Novi, Mich. (see photo above). The keynote speaker will be Michael Shinedling (photo at right), advanced engineering manager, SRT engineering, for Chrysler's (Auburn Hills, Mich.) SRT Design and Motorsports group. (See the new *SRT Viper Special Edition* model in *CT's* "2014 NAIAS Review" car show coverage, in this issue, on p. 19.)

Replete with presentations from automotive composite materials and equipment suppliers, the conference program will focus, in part, on advanced composites technologies that offer carmakers more opportunities to lightweight vehicles yet maintain or improve their performance. CompositesWorld is firming up the agenda for the conference. Confirmed speakers include Mark Minichelli, director, technical development, BASF Performance Materials (Budd Lake, N.J.) and Bob Davies, CEO, Fibrtec Inc. (Atlanta, Texas). Minichelli will address the replacement of steel in an automotive seat backframe with thermoplastic composites, and will discuss integration of continuous fiber reinforcements into the injection molding process. Additionally, he'll identify ways and means to improve system costs, predict structural performance using advanced CAE software, and correlate CAE predictions to actual test performance. Davies will address the use of nylon and tailored


Source | Chrysler

fiber-placement preforms. Topics will include an introduction to flexible thermoplastic prepregged tow; hybrid preforming using fabrics, uni tape and tailored fiber placement, and rapid consolidation methods.

Speakers also will be on hand from other well-known names: Aonix, BASF, Celanese, Engel, Fibrtec, LANXESS, RocTool USA, TenCate Performance Composites, and Wittmann Battenfeld. Aonix (Ottawa, Ontario, Canada) will present a discussion of its high-performance, amorphous UltraMaterials Solution polymers (modified paraphenylene, sulfone and polyimide systems) that enable very rapid manufacturing in the company's EXPRESS molding machines, for high-performance structural parts.

The ameri*mold* show will give attendees access to another new conference program — situated alongside ameri*mold*'s traditional programs for moldmakers — that will provide up-to-date information on the latest advances in thermoplastic manufacturing technologies, and expose its audience to advances in composites fabrication technologies that may become part of their processing operations in the future. For composites-industry companies that are looking for an entrée into automotive production, this event will feature a two-pronged thrust, exposing them to new technologies in their field, and enabling them to rub shoulders with injection molders that already are part of the automotive supply chain.

For more about the conference, show and registration, visit short.compositesworld.com/TCC2014.

Toray plans U.S. expansion for Americas: Carbon precursor/fiber/prepreg lines?

Toray Industries Inc. (Tokyo, Japan) announced on Feb. 17 that it has purchased about 400 acres of commercial land for "future business expansion" in Spartanburg County, S.C. Although Toray did not explicitly state the purpose for the U.S. land acquisition, the property's proximity to Boeing's South Carolina 787 aircraft assembly plant, and Toray's recent purchase of a 20 percent share in U.S.-based automotive composites specialist Plasan Carbon Composites Inc. (Wixom, Mich.) strongly suggest that the site will accommodate carbon fiber manufacturing: Toray reportedly has been considering a plan to build an integrated carbon fiber production facility that would incorporate spinning operations for precursor fiber as well as carbonization and prepregging lines.

Toray says it expects the U.S. to regain its industrial competitiveness on the back of the ongoing shale gas/oil revolution and a resulting revival in manufacturing. The company, therefore, expects U.S. demand for its TORAYCA prepreg to grow not only in aircraft but also natural gas pressure vessel applications and sees the U.S. as its access point to Latin American markets (i.e., Mexico and Brazil). Toray plans a total investment of roughly ¥100 billion ($978 million USD) in its U.S. operations by 2020, and made clear that the land acquisition also will figure significantly in mid-term plans to expand in other emerging economies.

2014 North American International Auto Show Review

Detroit's annual automotive industry showcase highlights the rapid pace of innovation.

The 25th anniversary of the North American International Auto Show (NAIAS) was celebrated at the Cobo Convention Center (Detroit, Mich.) in January, giving visitors a chance to view dozens of new production vehicles, models and concept cars, as well as providing them with an up-close look at the rapidly changing face of the industry. In the quarter century since the Detroit Auto Show morphed into NAIAS, auto OEMs have introduced more than 1,300 new vehicle models here — 81 percent of them have been first-time, worldwide unveilings.

As at previous shows, technological change was in the spotlight. Most newsworthy was the *rate* of change: The pace of innovation in recent years has accelerated, with robust competition for markets as auto OEMs face unprecedented technical challenges. Many spring — no surprise — from the progressively stringent fuel economy/emissions standards now in force on both sides of the Atlantic. CAFE standards in the U.S., for one, will require manufacturers to achieve a fleet average of 35.5 mpg by 2016 and then hit 54.5 mpg by 2025.

Source | CT / Photo | Michael LeGault

General Motor's (Detroit, Mich.) Chevrolet *Corvette* has always been an auto composites showcase. The 2015 *Corvette Z06*, above, won the 2014 NAIAS Car of the Year award.

Composites and other lightweight materials are expected to play integral roles in the design and manufacture of this next generation of vehicles. An already realized case in point is the much-discussed BMW *i3*, BMW AG's (Munich, Germany) first fully electric vehicle, which made its North American debut at the show.

Source | CT / Photo | Michael LeGault

The Chrysler Group's (Auburn Hills, Mich.) *SRT Viper* comes standard with a carbon fiber roof, hood and liftgate and a number of composite substructures. On display was this *Viper GTS Anodized Carbon Special Edition*, featuring a metallic matte exterior color, which will be available to 50 prospective owners in 2014.

The car features a 22-kWh lithium-ion battery pack, and a passenger cell and other parts constructed of lightweight carbon fiber composites. Significant, here, is the back story: The *i3* incorporates carbon fiber supplied by SGL Automotive Carbon Fibers (Moses Lake, Wash.), a joint venture of BMW Group and SGL Group. SGL ACF produces raw fiber from a polyacrylonitrile (PAN)-based textile fiber precursor. The Moses Lake plant now has two production lines running. Together, they are capable of producing a total of 3,000 metric tonnes (6.6 million lb) of fiber per year. The fiber is shipped to Germany where, in another SGL ACF facility in Wackersdorf Innovation Park, they are processed into fabrics. These are cut and assembled into preforms and used to mold parts in a high-pressure resin transfer molding (HP-RTM) process.

The four-door *i3* is 157 inches long and 62 inches high (399 cm by 157 cm) and, powered by its 170-hp electric motor, reportedly can accelerate from 0 to 60 mph in seven seconds. Fully charged, the car's driving range is said to be 80 to 100 miles (130 to 160 km). Sources at the show said the car's first deliveries to U.S. customers are expected in May, and they reported the company has 11,000 confirmed orders on the books for this year.

BMW also announced that it plans to start production of its first plug-in hybrid, two-plus-two sports car, the BMW *i8*, in the second quarter. Like the *i3*, the *i8* will feature a passenger cell ►

Source | CT / Photo | Michael LeGault

Making its world debut, Nissan Motor Co.'s (Yokohama, Japan) *Sport Sedan Concept* car embodies design features intended to appeal to younger buyers. These include carbon fiber accent components in the front fender and headlamp bezel, and ground effects.

Source | CT / Photo | Michael LeGault

Nissan's luxury brand, Infiniti, showed off its *Q50 Eau Rouge* concept. Envisioned as the company's entrance into the performance-car market, the new design features carbon fiber exterior ground effects and carbon fiber interior detailing. The company says the concept will go into commercial production in the next few years.

and other parts made from carbon fiber. (Any lingering doubt in the auto industry about BMW's commitment to manufacture carbon fiber auto parts was subsequently dispelled in mid-February, when both *i3* and the *i8* got significant play in BMW's TV advertising campaign during the Sochi Winter Olympics coverage.)

The winner of the 2014 NAIAS Car of the Year Award, General Motors' (Detroit Mich.) 2015 Chevrolet *Corvette Z06*, was on prominent display (see photo, p. 19), repackaged with a supercharged 6.2L V8 engine that delivers more than 625 hp. Like all the 7th generation *Corvette* models, the *Z06* comes with a standard carbon fiber hood. Additionally, its Coupe version features removable carbon fiber roof panels. Notably, all the 7th generation models are manufactured with a substructure made from a carbon nanocomposite. The substructure connects the body panels to the chassis. The carbon nanofilled composite components reportedly save about 9 lb/4 kg compared to previous versions molded from sheet molding compound (SMC).

New to the *Z06* is a carbon fiber torque tube, which connects the engine to the rear-mounted transaxle. The car also comes with an optional carbon fiber aerodynamic package, which includes a front splitter with winglets, rocker panels and a larger rear spoiler. The *Z06* package also includes carbon-ceramic composite brake rotors.

In 2012, Chrysler Group's (Auburn Hill, Mich.) SRT (Street and Racing Technology) brand issued a completely redesigned version of its *SRT Viper*. All standard *SRT* models come equipped with a hood, roof and liftgate molded from carbon fiber prepreg by Plasan Carbon Composites (Bennington, Vt.). Additionally, the windshield frame features a glass/carbon fiber SMC, facilitating, in total, a 32 percent weight savings compared to the previous, all-metal model.

SRT also launched the limited-run *Viper GTS Anodized Carbon Special Edition*. Its metallic matte exterior color (see photo, p. 19) accentuates the vehicle's styling, according to SRT officials. "The *Viper's* unique, hand-built and hand-painted process allow us to create these ultra-exclusive special series builds," said Ralph Gilles, president and CEO of Chrysler's SRT Brand and Motorsports group. The car's interior features carbon fiber accents throughout, in the center stack, door panels, steering wheel and dashboard. The company plans to build about 50 *Special Edition Vipers* in 2014. SRT also revealed a new "Stryker Green" color for the *Viper* at the show.

Nissan Motor Co. (Yokohama, Japan) displayed a number of concept sports cars intended to capitalize on innovative trends in product design and development yet also appeal to more youthful customers. The company's *Sport Sedan Concept* car (p. 20) made its world debut in Detroit, with multiple carbon fiber accent components in the front fender and headlamp, as well as carbon fiber rocker panels and a ground-effects package.

Nissan's luxury brand, Infiniti, introduced the *Q50 Eau Rouge* concept, a heavily modified version of its production *Q50*, envisioned as the company's entry into the performance-car market segment. Although it's labeled as a concept car, Infiniti president Johan de Nysschen "absolutely insists" that it will be put into production, perhaps as early as the 2016 model year. The vehicle, built around either a V-8 or a turbocharged V-6 capable of generating more than 500 hp, would be on par with performance cars produced by BMW, Audi (Ingolstadt, Germany) and Mercedes-Benz (Stuttgart, Germany). The car on display was built with SMC body panels, and carbon fiber exterior ground effects and interior detailing. | CT |

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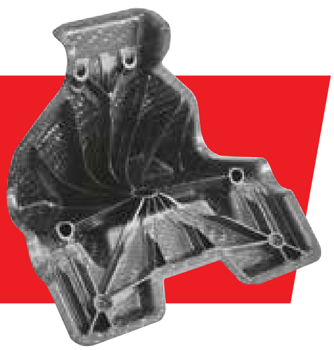

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Composites for heavy truck

TOUGH-DUTY INSPECTION COVER

Thermoplastic composite reduces weight, cost, corrosion, extends maintenance intervals.

As they have in passenger cars and light trucks, reinforced plastics are gaining ground in underhood and powertrain applications on commercial trucks. Progress, however, has been slower because the abuses to which big trucks are subject — heat, aggressive chemicals and, in some cases, stone impacts — are far greater. Further, these vehicles are operated orders of magnitude more miles/kilometers per year and have service lives that can stretch to decades. Despite these challenges, truck OEMs, like automakers, face increasingly tough fuel-efficiency and emissions standards and (this comes as no surprise) the features that make composites attractive for passenger vehicles — lower cost and mass, opportunities for parts consolidation, corrosion resistance and noise-damping characteristics — have the same allure for heavy trucks. Another benefit, lower tooling investment, has even greater impact on the big-truck bottom line because parts are larger and build volumes are far smaller, giving composites a cost advantage vs. metals at most production volumes.

Although thermoset composites made the first inroads into heavy trucks, forming valve covers, timing-chain covers, oil pans and intake manifolds, more impact-resistant and more quickly processed thermoplastic composites are now claiming a share. An excellent example is the transaxle inspection cover assembly on CRD 150/1 drive axles produced by American Axle Manufacturing Inc.

Source | Mack Trucks

Source | SPE Automotive Div.

A thermoplastic composite has replaced cast aluminum in the transaxle inspection cover assembly on the CRD 150/1 drive axle produced by American Axle Manufacturing Inc. (Detroit, Mich.) for tandem-axle line-haul, refuse, dump and mixer trucks like this one, built by Mack Trucks Inc. (Greensboro, N.C.). The two-piece assembly, molded by Sturgis Molded Products (Sturgis, Mich.), features a 55 percent short-glass-and-mineral reinforced Reny PA-MXD6 aromatic polyamide.

(Detroit, Mich.) for Mack Trucks Inc.'s (Greensboro, N.C.) tandem-axle line-haul, refuse, dump and mixer trucks (sold under the *Pinnacle*, *Granite*, *TerraPro*, and *Titan* badges). The two-piece assembly (one assembly per axle) comprises a cover with four molded inserts, plus a magnet (which pulls metal shavings out of the transaxle fluid and is bonded in a later step).

The part is injection molded by Sturgis Molded Products (SMP, Sturgis, Mich.) using 55 percent short-glass-and-mineral-reinforced Reny PA-MXD6 aromatic polyamide (PA) from Mitsubishi Engineering-Plastics Corp. (Tokyo, Japan). It replaced a multipiece cast aluminum assembly (which had replaced one of machined steel) and reduces piece price by 20 percent and weight by 40 percent (from 3.8 lb/1.72 kg to 2.2 lb/1.0 kg). It was hailed as the first thermoplastic transmission cover for heavy industry.

THE APPLICATION THAT ALMOST DIDN'T HAPPEN

Interestingly, this all-thermoplastic breakthrough didn't make it into production on the first go-around. At that time, SMP was working with a different customer who was then American Axle's Tier 2 source for the inspection cover. "We had been working with the cover assembly supplier for about 14 months, looking at different types of materials and prototyping them," explains Christopher J. Emery, SMP's VP, sales and marketing. But just as SMP established that the Reny polyamide could meet the application's demanding requirements, the aluminum supplier for the existing part learned that the new thermoplastic prototype had passed muster in testing and could offer a less-expensive solution. "The cost of the incumbent die-cast material suddenly became much lower," Emery recalls wryly, "which essentially wiped out the benefit of switching from metal to plastics." Accordingly, that customer shelved the application and stayed with aluminum.

"Despite the disappointment we felt," Emery notes, "we knew this was a winning application." For that reason, he kept in touch with Mack. Nothing happened for about two-and-a-half years, but then: "Out of the blue, one day, I got a call from Mack's purchasing department, asking if we were still interested in pursuing this application."

Emery and his team soon learned that the original Tier 2 supplier had lost American Axle's business and the new Tier 2 was quite keen to explore alternative materials. "Of course, plastic doesn't corrode," adds Emery, "so going into this a second time, we knew we had more to offer the project."

Indeed, that phone call kicked off a new program. Although SMP had spent more than a year on research with the first Tier 2, the company redesigned, prototyped, validated via a battery of tests, and then rolled out a thermoplastic composite cover for the new Tier 2 in less than 20 weeks.

TOUGH-DUTY TESTING

That does *not* mean the roll-out was easy. The part had to meet *very* challenging validation requirements. And although SMP conducted dimensional analyses at its in-house metrology lab, all testing was done by the Tier 2 and, ultimately, by the OEM. To meet the modified Society of Automotive Engineers (SAE, Warrendale, Pa.) J400 spec, for example, the cover had to survive gravel bombardment at -40 ^{O}F and at 300^{O}F (-40 ^{O}C and 149^{O}C). In this test, some leakage is inevitable, but the cover must not crack or leak more than 279 cm^3/min (0.7 gal/min) at 5 psi/35 KPa (no more than had leaked from the aluminum cover). It also had to pass a 24-hour thermal cycling test (modified SAE J1455), which involved 6 hours at -40^{O}F/-40^{O}C, followed by 14 hours at 250^{O}F/ 121^{O}C and then 15 minutes at a peak of 300^{O}F/149^{O}C. The covers were tested with O-rings (70 durometer, ASTM:3CH 720 A25 B14 E16 E36) and, again, could not leak more than 279 cm^3/min at 5 psi. Tests also included chemical compatibility with transmission fluids (Bulldog 80W90 and Emgard EP75W90 types) and dimensional integrity to ensure the cover didn't leak and that it would provide easy access to the transaxle. For the latter, the assemblies were subjected to six removals and remounts with both iron and aluminum fixtures, during which the covers could show *no* warp or bushing wear. Lastly, they had to pass accelerated field tests on vehicles, during which they were subjected to hot/cold temperature cycling and onroad driving. Reportedly, critical part dimensions for composite covers were held to ± 0.007mm (± 0.0003 inch) with no warpage.

Beyond weight and cost savings, the composite assembly also provides tighter tolerance control, reducing leaks vs. its aluminum predecessor. Much credit for this advantage can be attributed to the selection of the aromatic polyamide. It is known for its high glass-transition temperature (T_g) of 469^{O}F/243^{O}C, high stiffness and strength, chemical stability, and long-term creep resistance — features vital for a tough-duty application on vehicles with long service lives. Going into the program, the supply team knew that long-term compression, deformation and warpage that might occur between attachment bolts were absolutely unacceptable, because each fault could permit leakage and, therefore, would necessitate adding bolts (and cost) to secure a tighter seal, something the tier supplier wanted to avoid. Although PA 6 and 6/6 polymers have a penchant for absorbing water and swelling, the aromatic grade's polymer ►


Source | Sturgis Molded Products

This photo shows the previous aluminum cover after long use on a truck transaxle. Conditions seen by the cover in this location led to corrosion and leakage of transaxle fluid. The new cover's tough aromatic polyamide reportedly eliminates the corrosion, lengthens service intervals and reduces part weight and cost. ■

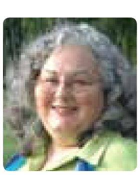
backbone reportedly presents fewer attachment sites for water molecules, and, therefore, is less prone to moisture uptake and resulting dimensional change. In fact, the resin exhibits less than 2 percent elongation over time and is said to offer creep resistance that is superior to that offered by PA 6, 6/6, and more exotic PA 12, eliminating cover-to-transaxle-housing gaps between fastener locations. Additionally, the chemical structure of the resin promotes good flow at lower injection pressures during the molding process. This facilitates precise molding even when part wall thickness varies between 2 and 8 mm (0.8 and 0.3 inch) along the same flow path.

GREAT, BUT COULD BE EVEN BETTER

In production since July 2006, the cover reportedly has netted Mack Trucks Inc. additional savings on freight and fuel-cost savings for operators, due to its reduced mass. Unlike the metal versions, the composite cover's bushings are insert-molded, which eliminates the need for the postmold hole drilling and tapping operations that otherwise would be necessary for two bolts that are now no longer needed. Additionally, the corrosion-free aromatic polyamide eliminates red rust, an issue with the original steel cover. Further, service of the assembly is said to be easier because the lighter cover requires less force to remove and replace. And the composite's noise-damping properties make for a quieter transmission without the use of secondary sound-abatement components, which would increase assembly cost.

That said, the cover project could have yielded even greater benefits. Although a few modifications were allowed, for the most part, SMP and Mitsubishi were stuck with a cover geometry that had been optimized for metals. The design, therefore, couldn't take full advantage of the composite's capabilities. For example, the new cover does feature an integrally molded oil-drip pan — previously a separate component that directs the flow of transmission fluid over the magnet — and the critical O-ring seal seat (channel) is molded in. However, the magnet is still attached in a separate operation, when it could easily have been insert molded. The O-ring, added in a secondary step, also offers the possibility, under the right conditions, of being molded-in.

As impressive as the part is, and as significant as the weight savings that the thermoplastic was able to deliver, "there still are plenty of ways we could take further weight out of the assembly," Matthew Orlando, Mitsubishi's business development director, concludes, "*if* we had the opportunity to redesign it from scratch." | CT |



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Source | Hennecke

PROCESSING WITHIN THE PUR cure window

Composite spray molding enables volume production of fiber-reinforced polyurethane sandwich structures for auto interiors. Are Class A exterior parts next?

Polyurethane resin systems (PURs) offer a host of inherent processing and performance properties that could be advantageous to automakers. Cured PURs exhibit greater stiffness at lower weight than polyesters and vinyl esters. Like epoxies, PURs are styrene-free but they already exhibit the "snap-cure" that epoxy resin manufacturers have only recently managed to formulate into their products (see "Learn More," on p. 33). PURs, historically, have been limited to small parts or to continuous processes, such as pultrusion, because the fast reaction time and rapid increase in viscosity after PUR's two components, polyol and isocyanate, are mixed permit precious little opportunity to wet out a reinforcement and then form the impregnated material prior to cure onset. That effectively put large parts out of reach. Polyurethane's greatest asset, an almost instantaneous cure, was also its greatest liability.

In recent years, that's changed. One approach has been to reformulate PURs to permit reasonable delays in the onset of gel and cure after the PUR's two parts have been combined. That was the goal with a novel polyurethane-based resin system with *tailorable* pot life and cure, developed by Huntsman Polyurethanes (Auburn Hills, Mich. and Everberg, Belgium). Formulated and introduced in late 2009, the trademarked VITROX resin system combines isocyanates, polyols and a proprietary catalyst system that permits processors to "dial in" the desired gel time and viscosity profile. The new formulation makes polyurethane practical for use in resin transfer

A potential application for Composite Spray Molding (CSM) is sandwich-construction exterior auto panels, such as this preproduction hood (depicted here in a CAD rendition) produced by automotive supplier Magna Steyr (Graz, Austria) and materials supplier Rühl Puromer GmbH (Friedrichsdorf, Germany) in a production cell built by Hennecke Inc. (Lawrence, Pa.). Designed to meet the European Union's pedestrian safety standard, it comprises a sandwich structure with paper honeycomb core (grey area), compressed between two layers of glass-reinforced polyurethane (green and black) manufactured in a two-step process that combines CSM with a vacuum reaction injection molding process that adds a Class A surface.

molding (RTM), vacuum-assisted resin infusion, filament winding and other processes in which processing times previously exceeded conventional PUR's short gel/cure curve (see "Learn More," p. 33).

A parallel development, however, *adapts the molding process* to a PUR system's inherent cure properties. In league with machinery specialist Hennecke Inc. (Lawrence, Pa.), Bayer MaterialScience (Pittsburgh, Pa.) conceived and commercialized composite spray molding (CSM), a method that enables large-part production using PUR, with auto-industry-acceptable speed and finished-part performance.

The process makes use of Bayer's sprayable Baypreg F polyurethane resin system. Although it's important to note that Baypreg F (like Huntsman Polyurethane's VITROX formulation) features a heat-initiated cure and delayed gel onset (up to 15 minutes), in the auto industry, where the part-per-minute mantra is the defining expectation, *delay* of cure *can't* be the goal. The CSM system is designed to *eliminate* processing delays so that auto parts suppliers can take full advantage of PUR's classically rapid cure cycle in the molding of large auto components.

GETTING IN ON THE BOTTOM FLOOR

The first automotive application for Baypreg in North America was a sunroof shade, which went into production in 2002. But today? Although several suppliers still mold PUR composite sunroof shades, the majority of recent applications are almost exclusively glass mat-reinforced polyurethane load floors, which are coverings for cargo storage areas or spare-tire compartments. Here, CSM has found a significant niche where PUR's low mass contributes to fuel economy, its stiffness renders the structure more resistant to deflection (a top design priority) and low cost is key.

Typically, a load floor is a sandwich construction, which, by design, yields a high stiffness-to-weight/cost ratio. Sandwich panels are constructed with prepreg or layed up "dry" and resin infused, processes far too slow for auto production rates. PUR wasn't practical in either scenario because it presents unique difficulties to those who would B-stage them as part of a prepreg, and because conventional PUR, although its initial viscosity is infusion-suitable, gels too quickly to be practical for infusing a large part.

CSM with Baypreg, however, is enabling load floor manufacturing by a number of suppliers. CSM is attractive to load floor molders because it employs processing equipment with which many automotive tier suppliers are already familiar. CSM combines *sprayup* and *compression molding*, methods introduced to automakers more than a decade ago. These familiar processes are combined with robotics (robots are familiar fixtures on today's auto assembly lines). Together, these minimize the time for fabric impregnation and hasten part completion.

The typical CSM load floor comprises a paper honeycomb core between layers of polyurethane-impregnated glass mat. Glass mat, from 1.0 to 3.0 oz/ft^2 E-glass, is either manually wrapped around the paper honeycomb or pre-attached to a honeycomb core with an adhesive. Bayer MaterialScience's Merle Lesko, associate scientist, polyurethane application and development, says the load floor panels can be as large as 3 ft by 4 ft (0.91m by 1.2m). One of the more standard designs employs a paper honeycomb core with a thickness between 10 and 20 mm (0.39 and 0.79 inch.) The glass content of the part's cured faceskins is within the range of 40 to 55 percent.

Although production lines can differ, a CSM production cell arrangement incorporates two polyurethane mixing heads, which are stationed across from one another under a ventilation fume hood. The resin's isocyanate and polyol components are stored in temperature-controlled day tanks at 75°F to 85°F (24°C to 29.5°C) before they are pumped into a high-pressure mixing head, which impinges the components at about 2,000 psi.

As the process cycle begins, a robot retrieves a honeycomb-cored glass panel and passes it between the mixing heads, where both sides are sprayed simultaneously with Bayer's Baypreg F polyurethane. This permits thorough wetout of large-area reinforcements safely within Baypreg F's out-time window.

After it is sprayed, the impregnated panel is placed by the robot in a mold stationed within a compression or stamping press. Constructed of P20 steel, the mold is electrically heated, because Baypreg F's cure is heat-activated. The minimum mold temperature is usually 185°F to 190°F (85°C to 87.8°C), although to accelerate cure, Bayer recommends 215°F to 225°F (101.7°C to 107.2°C).

Source | Bayer MaterialSciences

Commercial load floors and sunshades are now in production, made via a Composite Spray Molding process, using Bayer MaterialScience's (Pittsburgh, Pa.) Baypreg polyurethane resin system. Pictured here is a test panel, showing the assembled glass mat/paper honeycomb package before spraying.

According to Bayer, part spraying and transfer can be accomplished within 75 seconds and typical part cure and demold time is a mere 60 seconds or less.

One of the big process variables is *inmold cavity pressure*. This can vary widely depending on the construction of the mold, which, in turn, is determined by the molder's expectations in terms of part edge treatment. Mold options, generally, fit into three categories:

- A mold that produces a part that will require post-mold finishing and trimming (no provision is made for in-mold edge treatment).
- A mold with a *pinch edge*. This forms the edge of the part perimeter in a way that still requires post-mold trimming, but facilitates a more efficient trimming operation.
- A mold with a "shear edge," which cuts away all material outside the parting line during the molding process, producing a finished part out of the mold. Other postmolding procedures include application of carpeting to one or both sides and the attachment of latches and bezels.

Molds without a pinch or shear edge are typically used to produce relatively flat panels, and here, inmold pressure can be as low as 30 psi. If this type of mold is used to form a part with some draw or curvature, the inmold pressure would typically need to be about 60 psi. Molds designed to yield a part with a pinch or shear edge, however, require higher but still easily managed 120 psi.

Lesko says CSM is ideal for sandwich panels because the relatively low pressures used in the process keeps most of the polyurethane and glass on the surface of the honeycomb, yielding a lightweight part with good deflection properties. Alternative PU technologies such as long fiber injection (LFI), he says, would result in intrusion of the glass/resin matrix into the core. The cavity pressure range also permits capital cost savings: Lesko reports that a comparatively inexpensive 150-ton press would be adequate to mold a 3-ft by 4-ft

Source | Bayer MaterialSciences

An assembled glass mat/honeycomb sandwich before spraying (left) and a finished panel that has been sprayed, placed in a heated mold in a compression press and cured.

This cross section of a finished 16-mm/0.63-inch sandwich shows the honeycomb core and glass-reinforced PUR faceskins that form a panel resilient enough to withstand the foot or knee of a 250-lb/113-kg person and return to its original shape.

Source | Bayer MaterialSciences

load floor. "If you were molding the same load floor in gas-assisted injection molded plastic," he points out, "you would need a machine in excess of 1,000 tons." But Lesko reports that it is the *weight savings* that are driving automaker conversion to the PUR-CSM system. PUR-CSM can result in weight reductions of as much as 70 to 80 percent vs. gas-assisted injection molded plastic load floors (these all-plastic, hollow constructions have no core or fiber reinforcement to increase stiffness and reduce structure weight). PUR-CSM reduces weight by 30 to 35 percent vs. a wooden floor.

Bayer's engineering group provides design support to OEMs and suppliers interested in converting load floors and other parts to CSM sandwich honeycomb structures. Support includes CAD part workup and finite element analysis to determine the part thickness and glass weight necessary to achieve the required deflection limits under loading, retain shape memory and return to original form after loading. Deflection, the key performance parameter, is minimized through computer modeling. Part performance is validated in the lab via physical tests that simulate the applied force of a knee or foot of a 250-lb/113-kg person to ensure the resulting deflection stays within the limits specified by the customer's drawings.

ROOM TO GROW

Despite an abundance of conversions to CSM-manufactured load floors in recent years, Lutz Heidrich, Hennecke's director of sales, estimates that at least 80 percent of the load floors now in production are still made from gas-assisted injection molded plastic, wood or other materials. "There's a huge potential for conversion and growth in this one automotive application," he notes, "because there's still so many manufacturers who haven't caught on to the benefits."

Source | Bayer MaterialSciences

This finished plaque shows the result when the sprayed sandwich panel is demolded after curing at 185°F to 190°F (85°C to 87.8°C). Typical curing and demold time is 60 seconds or less. Total glass content of the finished part can range from 40 to 55 percent. Postmold operations usually include application of carpeting and attachment of latches and bezels. Bayer estimates a weight saving for PUR-sandwich load floors of 70 to 80 percent vs. gas-assisted resin injection molded plastic.

Although the specific equipment used to mold parts for each supplier is proprietary, Heidrich reports that Hennecke can supply turnkey PUR-CSM work cells for the manufacture of sandwich composite parts. Depending on the customer's requirements, a typical manufacturing cell could include a glass cutter, a station for manually assembling the glass mat/paper honeycomb sandwich, a robot, a spray booth where the sandwich gets robotically sprayed with polyurethane and a clamping or compression press. The company also offers a patented self-cleaning mixhead, which uses a hydraulically operated ejector to keep lines clean after each shot. This enhances production efficiency and reduces cost. "Being able to start and stop the process saves you material costs and allows you to avoid using cleaning solvents," Heidrich adds. The mix heads are capable of output rates that range from 5 to 800 g/sec.

FROM INTERIOR TO EXTERIOR

Hennecke also is collaborating with automotive supplier Magna Steyr (Graz, Austria) and materials supplier Rühl Puromer GmbH (Friedrichsdorf, Germany) on a new automotive exterior application that, if successfully commercialized, could be a harbinger of new growth for parts made by the CSM process. The part is a preproduction hood (bonnet), designed and built for a commercial car model produced by a major German OEM.

Gunter Wolfsberger, Magna Steyr's product manager, composite fiber technology, says its first-generation sandwich composite hood in 2011 featured *carbon* fiber reinforcement. But when the hood had its first public showing at the 2013 K Show, it featured a second-generation design that, like the load floors, combined a paper honeycomb core and *glass* fiber-reinforced faceskins. This design complies with the European Union's Global Technical Regulation no. 9 on pedestrian safety by facilitating greater energy absorption in the event of a collision with a person. (The regulation is binding, but its implementation date has yet to be decided as industry develops the necessary technology during the transition period.) The hood's dimensions are 1,385 mm long by 1,550 mm wide with a maximum draw/curvature of 160 mm (54.5 inches by 61 inches by 6.2 inches of draw), but part weight is a mere 7.1 kg/15.6 lb.

Wolfsberger says Magna Steyr's generic hood-manufacturing process proceeds as follows: Carbon fiber mesh fabric or glass mat is laid up on either side of a paper honeycomb core. The sandwich is sprayed with PUR and placed in a heated tool inside a compression press. Rühl Puromer is the supplier of the complete system, including the polyurethane, trademarked puropreg. The paper core is crushed together with the PUR-impregnated fibers to ensure a good core/skin bond, a critical step that is variously referred to as *crush* *core* or *wet pressing technology*. The part is cured, removed from the mold and trimmed using a milling process.

Next, Rühl Puromer's trademarked purorim reaction injection molding process is used to apply a Class A surface finish. The cured part is placed into a mold inside a compression press, where a vacuum reaction injection molding process is used to add an outer polyurethane skin layer of 0.6 to 0.8 mm (0.02 to 0.03 inch) thickness onto the part's exterior surface. The total cycle time for the complete two-step molding phase of the operation is about 280 seconds (4 minutes and 40 seconds). The part is painted offline. Postmold fiber content of the hood (either carbon or glass) is in the range of 45 to 60 percent by volume.

The design of the hood capitalizes on one of the essential mechanical properties of composite paper honeycomb structures: energy absorption and crash protection. From an engineering and performance standpoint, Heidrich likens the honeycomb to an I-beam, with hard surfaces on the top and bottom separated by a core filled with compressible air that generates a force "normal" to both surfaces, resulting in good energy absorption and deflection properties.

Wolfsberger says the second-generation technology that Magna Steyr used to manufacture the glass-reinforced PUR hood sandwich is commerical production-ready. He also reports that in addition to hoods, the process can be used to make other exterior body parts that require Class A surfaces, such as roofs, retractable hardtops and door panels. Further, Rühl Puromer is collaborating with a number of OEMs to commercialize the process.

Although automotive applications for PUR-CSM honeycomb sandwich parts are in their relative infancy, the robust growth of recent years would appear, if anything, likely to accelerate as the industry explores alternatives for lighter, safer vehicles. | CT |

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Read this article online | short.compositesworld.com/PURinauto.

Read more about Huntsman Polyurethane's delayed-onset-cure PUR in "A new 'tunable' polyurethane could revolutionize composites" | *CT* February 2011 (p. 9) | short.compositesworld.com/tunablePUR.

The "snap-cure" properties of PURs and epoxies are discussed in the context of "Composite leaf springs: Saving weight in production suspension systems" | *CT* February 2014 (p. 34) | short.compositesworld.com/leafspring.

Styrene & cobalt

HEADED FOR THE EXIT?

The Chevy *Spark* electric vehicle, in development at General Motors (Detroit, Mich.), features a large composite battery tray (between the rear wheels), developed by Continental Structural Plastics (Troy, Mich.). The composite features Cytec's new MTM 23 prepreg, which features Reichhold's ADVALITE vinyl hybrid resin system, formulated with a petroleum-based styrene replacement. The resin reportedly offers mechanical performance on par with styrenated vinyl esters.

Whether or not — and to what degree — styrene and cobalt are harmful to humans has been the subject of debate for years in the U.S. and Europe. But even a cursory inspection of the studies and data surrounding these chemicals raises more questions than answers. Because these chemicals are important ingredients in some resin systems, the composites industry has, for many years, proactively sought to protect plant floor workers from exposure via inhalation or skin contact, through the use of protective clothing, respirators and other means.

At some point, however, the health discussion — once conducted primarily among governmental agencies, academic researchers and industry — spilled over into the public arena. There, even the *possibility* of harm began to taint styrene and cobalt, creating a public *perception* that use of these materials could (or would) lead variously to cancer, disease or death. That perception alone has sometimes had enough impact to redirect current and potential customer interest toward matrix resins that *don't* incorporate styrene or cobalt. In response, resin formulators have pragmatically decided that, despite the lack of real answers to the health questions, it's time to look for styrene- and cobalt-free solutions that, for those who use their resin products, render the health questions unnecessary.

HOW WE GOT TO THIS POINT

Styrene has been one of the workhorse ingredients in two of the composites industry's workhorse resins. An effective diluent and crosslinking enabler (it readily polymerizes when exposed to light or heat), styrene is used in loadings of up to 40 percent by weight in unsaturated polyester resin (UPR) and in vinyl ester resin. Corrosion resistance and high strength have long made these resin systems popular in the manufacture of watercraft, cultured marble countertops, solid-surface bath and kitchenware, polymer concrete and more. But their heavy use in open mold processes, combined with styrene's strong odor, have kept styrene under the wary eye of regulatory agencies as potentially detrimental to employee health.

Since the 1980s, a variety of state, national and international organizations have assessed styrene's health effects and deemed it not harmful to humans if managed according to accepted guidelines. Nevertheless, in 2004, the U.S. Department of Health and Human Services' (HHS) National Toxicology Program (NTP) received a recommendation from an anonymous source to reassess the health effects of styrene. The result was its decision, in June 2011, to list styrene in the *12th Report on Carcinogens* (*RoC*), officially labeling it as "reasonably anticipated to be a human carcinogen."

In Europe, the International Agency for Research on Cancer (IARC, Lyon, France) listed styrene as "possibly carcinogenic." But the EU's Registration, Evaluation, Authorisation and Restriction of Chemical (REACH) substances program proposes that styrene should not be classified as a carcinogen at all. (For a full report on styrene and its listing status, see "Learn More," p. 37.)

Cobalt, on the other hand, has faced greater scrutiny in Europe, but less in the U.S. The focus, however, has been on cobalt *metals*. In a July 2013 white paper, Tony Bennett, technical development manager, Thermoset Products Americas, at AkzoNobel Functional Chemicals (Chicago, Ill.), summarized cobalt's regulatory status: Cobalts used in UPRs are salts, called cobalt carboxylates, and function as promoters or accelerators, initiating gel and cure in combination with organic peroxide initiators. Cobalt naphthenate, cobalt decanoate, cobalt neodecanoate and cobalt octoate — also known as cobalt bis(2-ethylhexanoate) — are common in unsaturated polyester resins and coatings. The percentages of cobalt *metal* in these compounds vary.

Whatever form it takes, cobalt faces a potentially limited future in Europe and, by extension, throughout the world. Bennett reports that under REACH legislation, cobalt carboxylates were placed in evaluation by the European Chemical Agency (ECHA). In August 2012, cobalt bis(2-ethylhexanoate) was classified as CMR2 Reprotoxic. CMR stands for carcinogenic, mutagenic and reprotoxic (toxic to reproduction). It is possible that the research data could lead to cobalt carboxylate's reclassification as CMR Carcinogenic 1b. Already in Europe, some inorganic cobalt salts, such as cobalt sulfate, have been classified as lung carcinogenic CMR 1b, reproductive toxin category 1b and mutagenic category 2. With this classification, he says, each manufacturer is obligated to demonstrate the safety of cobalt-containing products. "A CMR Carcinogenic 1b reclassification of cobalt carboxylates will be a great challenge," Bennett says. "The effect of such legislation would restrict the use of cobalt carboxylates in manufacturing composites."

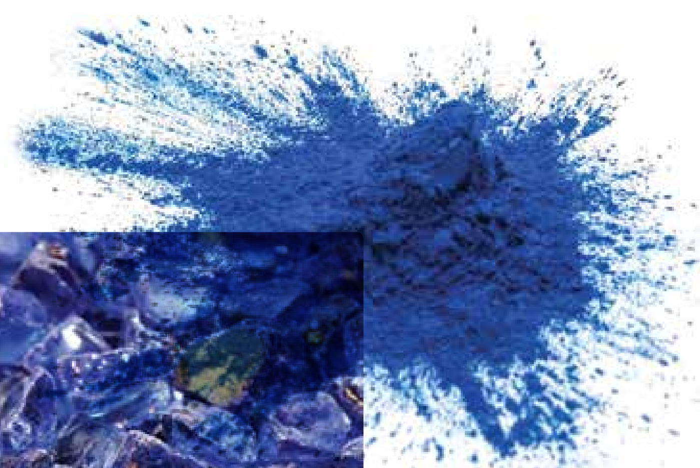
In the U.S., cobalt, like styrene, has faced scrutiny by NTP. In October 2013, NTP issued its findings in regard to the toxicology and carcinogenicity of cobalt metal in rats and mice. The study reported that there was repeated and "clear evidence of carcinogenic activity of cobalt metal."

MANUFACTURERS RESPOND

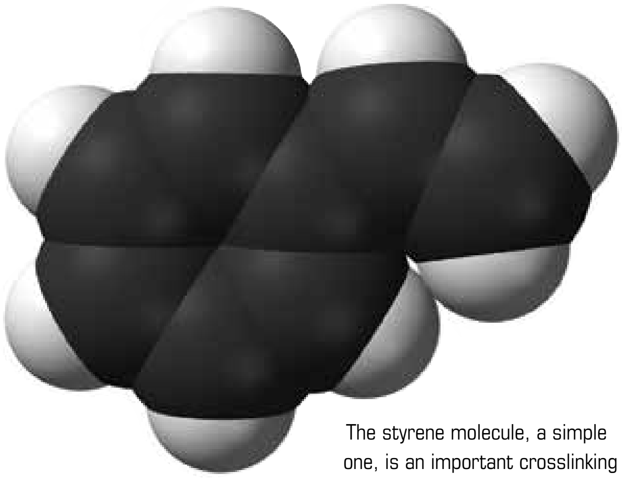
Styrene and cobalt found their way into resin formulations because they were not only highly effective, but also inexpensive and plentiful. That and familiarity has made finding replacements difficult. The composites industry, in fact, has become so dependent on these materials that any replacement, no matter how effective, is likely to be deemed inferior by some measure. Indeed, until recently, the best-performing styrene replacements that had come to market presented cost hurdles that handicapped the marketability of styrene- and cobalt-free UPRs and vinyl esters. But there is great impetus for resin formulators and their chemical suppliers to continue to pursue new, more affordable chemistries. Although there are not yet true *drop-in* replacements for styrene and cobalt, such a goal is within reach.

Because it's been a regulatory target for longer, styrene has received the most attention. Researchers have sought replacements *and* worked to minimize styrene emissions on the shop floor. The latter, after all, is the primary concern of regulators. If styrene can be used without exposure to the workplace environment, then fabricators may continue to enjoy its benefits.

Emissions have been the strategic focus at BYK USA Inc. (Wallingford, Conn.), which 20 years ago introduced BYK-S 740 and 750, styrene emission reducers for UPRs and vinyl esters. Tom Delay, BYK's market manager for thermosets, says the additives are used in loadings of about 1 percent or less and work as film formers that trap styrene vapors within the composite components, thereby preventing them from escaping the part and entering the atmosphere. BYK recently introduced BYK-S 760, a next-generation styrene emissions reducer that is sourced primarily (85 percent) from renewable or "green" materials. Further, 70 percent of its ingredients contain unsaturated groups, which react with the resin during ►



Cobalt in salt form has been a main ingredient in vinyl ester and unsaturated polyester for many years, but concerns in Europe and the U.S. about the carcinogenicity of cobalt metals likely will mean that this chemical will soon face restrictions. Resin formulators are working on copper-based replacements. ■



The styrene molecule, a simple one, is an important crosslinking agent in vinyl ester and unsaturated polyester. But it's strong odor and heavy use in open-mold processes has brought it under significant governmental scrutiny.

polymerization. This has enabled BYK to gain food contact approval so it can be added to UPRs and vinyl esters used to mold products for food handling. Delay also claims that when the 740, 750 and 760 additives are used, "there's no negative effect on the mechanical properties of the part and secondary bonding is not a problem."

Replacing styrene is a more difficult task, and one that resin manufacturers have approached from several directions. One is to replace *some* of the styrene used in UPR and vinyl esters with materials sourced from *renewable, non-petroleum* ingredients. Another is to replace *some* of the styrene with materials sourced from other *petroleum-based* ingredients. The third, and most challenging, is to replace *all* of the styrene with an alternate *petroleum-based* monomer. It appears, however, that some solutions are near.

The most notable of these is ADVALITE, a new styrene-free vinyl "hybrid" just introduced by Reichhold Inc. (Research Triangle Park, N.C.). This reactive diluent-free resin system uses standard free-radical inhibitors and initiators, offers temperature resistance of up to 200°C/392°F, has low exotherm and no VOCs, and exhibits mechanical performance on par with styrenated vinyl esters. ADVALITE was recently used in MTM 23 prepreg, developed by the Industrial Materials Group at Cytec Industries Inc. (Woodland Park, N.J.). Cytec supplied MTM 23 to Continental Structural Plastics (CSP, Detroit, Mich.) for the fabrication of a composite battery enclosure for GM's latest electric vehicle (EV), the Chevy *Spark*.

Mark Steele, Cytec Industrial Materials' technical director, says MTM 23 is not a one-for-one drop-in replacement for styrene-based vinyl esters and, thus, must be processed differently. "The only processing accommodation is related to the differential in cure temperature and final T_g," he points out, but adds that "because there is a significant difference, parts must be cooled below the T_g of MTM 23, or supported when removed from the mold."

As might be expected, the cost of MTM 23 is not yet on par with styrene-based vinyl esters: "Styrene is an extremely low-cost monomer," reports Steele. "The components used to formulate MTM 23 do not have this low-cost base, so it is inevitable the manufacturing costs will be higher."

But Cytec argues that the proof of MTM 23's value is in the end product. GM's battery tray met a number of rigorous performance requirements, including 30° offset-barrier, side-impact, and rear-barrier crash; 50G impulse shock (x, y, and z); post-crash package integrity; fire-resistance testing; 3m/10-ft drop testing (bottom/end); a 1m/0.91-ft water-submersion test; and vibration/shock testing. Moreover, the compression-molded structure is 40 percent lighter than metallic solutions.

Cytec and CSP also worked together on data generation, ply design and press production technology. That collaboration enabled CSP to manufacture parts in cycles of less than 10 minutes at a 150°C/300°F cure. Cytec, however, contends that MTM 23 has the capability to be rapid-cured in less than three minutes.

Resin manufacturer AOC (Collierville, Tenn.) has packaged its styrene-free resins in its EcoTek line, with particular emphasis on underground sewer pipe rehabilitation applications. In the line is the EcoTek L704-FAHG-VT Series, a set of high-molecular-weight isophthalic/unsaturated polyester resins thinned with vinyl toluene. Another, EcoTek H164-ACAG-40, is a medium-reactive, styrene-free, thixotropic, prepromoted resin, designed for use in the manufacturing of boats and other composite parts via hand layup or sprayup.

In 2007, Reichhold introduced POLYLITE 32245, a line of low-styrene (less than 35 percent) casting resins, formulated as alternatives to orthophthalic-based resins used in engineered marble applications, such as integral bowl vanities and bathtubs. This medium-reactivity resin line's low viscosity reportedly allows higher filler loadings than conventional casting resins, thus reducing material costs, and is formulated for use with lightweight fillers, including carbonates. The resins are prepromoted for room-temp cure, using methyl ethyl ketone peroxide (MEKP).

Dixie Chemical Co. (Pasadena, Texas) formulates bio-based unsaturated polyesters (ortho-, iso-, and terephthalic, DCPD-modified and bisphenol A fumerate) and vinyl esters. In 2012, the company launched a bio-based partial styrene alternative for UPR and vinyl ester. Dixie's composite applications chemist Alex Grous says the methacrylated fatty acid (MFA)-based reactive diluent is derived from palm kernel and coconut oil. It is used in sheet molding compound (SMC) and bulk molding compound (BMC) and in resin systems designed for pultrusion, casting and resin transfer molding (RTM) processes. Applied in 15 to 18 percent loadings, MFA offers styrene emissions reductions of up to 27 percent, with good toughness and elongation, low-to-no odor and 60 percent bio-content.

Dixie has worked with partners Ashland, Premix (N. Kingsville, Ohio) and the Maine Composites Alliance (Portland, Maine) to develop parts and structures made with resins formulated, in part, with MFA. The Alliance recently assessed data on MFA loadings of 15 percent in vinyl ester for a construction application, and 18.6 percent in polyester for a marine application. Infusion times were either unchanged or slightly improved, Grous claims, with no sacrifice of toughness, flexural strength or other mechanical properties.

Cobalt replacement for composites applications is less evolved than styrene replacement is, but activity is starting to pick up. Among the most active is AkzoNobel, which began looking at alternatives a few years ago, mainly among other metals on the periodic table that are similar to cobalt. Copper in its natural state, Bennett says, actually hinders resin cure, but AkzoNobel found that if it was "excited" properly, it could be used to promote cure. This led to the development in 2006 of two copper-based compounds to promote cure of polyester resin, and one manganese-based compound that appears to function like cobalt does in parts for some high-temperature applications.

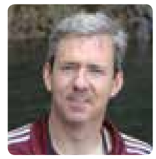
Bennett says that about this same time, two other companies were working on similar technologies, OM Group (Cleveland, Ohio), a manufacturer of chemicals, metals and other advanced materials, and DSM Composite Resins (Schaffhausen, Switzerland), a well-known manufacturer of matrix resins. Each company had filed patents relative to cobalt replacement and, Bennett says, there was much overlap in terms of cobalt replacement R&D. "We decided that we could continue to work alone, and block each other, or work together," he notes. As a result, an agreement between DSM and AkzoNobel was made, creating the BluCure product line and opening cobalt replacement technology, commercially, to the composites market.

Introduced in 2013, BluCure is administered by AkzoNobel and licensed to resin manufacturers or processors, who incorporate it into nonpromoted resins. So far, there are several licensees in Europe and one in the U.S.

Not always exact drop-in replacements, BluCure products "can require a little effort to match cobalt performance," Bennett says, depending on the application and the manufacturing process. "But new cure systems developed by AkzoNobel can surpass cobalt properties in some instances."

This is a product, however, developed in anticipation of more stringent REACH restrictions, which Bennett and other cobalt replacement enthusiasts believe are imminent. "There has not yet been a compelling reason to change, but the new BluCure technology shows improvement over cobalt in more challenging curing applications where traditional cobalt has limited effectiveness."

The ultimate regulatory fate of styrene and cobalt is unknown, but it is well understood in the specialty materials world that once a chemical lands on a regulatory "list" and is labeled, rightly or wrongly, as definitely or potentially carcinogenic, getting it off that list is almost impossible. Resin manufacturers understand this, so we can expect more aggressive development of styrene and cobalt alternatives. | CT |



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Read this article online | short.compositesworld.com/SCExit.

Read *CT's* previous coverage of regulatory uncertainty with respect to styrene | "Styrene: Issues and implications" | *CT* February 2012 (p. 25) | short.compositesworld.com/7rkRvlAk.

Applications

QUAY CABLE TRAY | Composites upgrade container ship terminal

In South Africa, the Transnet National Ports Authority of Cape Town operates a busy port with considerable container ship traffic. When it began a 12-month effort with a local civil engineering company to expand its facility and upgrade its existing quays (wharfs), engineers realized that the Authority had a safety problem at its main container quay: A raised cable tray runs along the quay's edge. More than 1,200m/3,900 ft long and 3m/10 ft wide, the tray contains the electrical cables that power the large, rail-mounted gantry cranes used to load and unload ships. The tray was a serious trip hazard for workers. In search of a safer solution, the engineering company approached Cape Town-based composite materials supplier and distributor **Aerontec**.

"Engineers had considered pouring a concrete layer at 190 mm [7.5 inches] thick to bring the quay edge level with the cable tray and the crane rail," says Graham Blyth, Aerontec's owner. But that solution weighed in at about 1,000 tons, he recalls. The quay's cantilevered deck and supporting piles weren't designed to carry the additional weight. Further, he notes, the concrete's "28-day cure time would have interfered with berthing ships."

The cable tray problem needed a solution that would be not only light in weight, but also provide safe footing and permit access to existing manholes and fire hydrants, yet be cost-effective and easy to install. The Ports Authority further specified that any seawater that might wash over the installation should drain away quickly, with minimal corrosion. Perhaps the toughest requirement, however, was that the solution should be strong enough to bear loads of up to 36.3 metric tonnes (80,028 lb) in the event a shipping container is placed, or dropped, within the cable tray area. Finally, the structure should be replaceable, if damaged, and prevent damage to the quay's underlying concrete surface.

Source | Aerontec

An iterative design and testing process resulted in large, monolithic resin-infused, fiberglass-reinforced polymer (FRP) panels. The 32-mm/1.5-inch thick slabs, formed from woven glass roving and isophthalic polyester resin, were coated with a UV-stabilized iso-NPG (neopentyl glycol) and a nonslip grip finish and drilled to create drainage holes. The reinforcement was woven to Aerontec's specification and supplied by **Vision Composites** (Winchester, U.K.) The resin, gel coat and flow-coating materials were sourced from two suppliers: **NCS Resins** (Pinetown, South Africa) and **Scott Bader** (Northamptonshire, U.K.). Aerontec partnered with composites fabricator MMS Technology (Centurion, South Africa) to manufacture and waterjet cut 1,161 panels of varying sizes, which were numbered for installation. Blyth explains that each panel was raised to the specified height using stepped solid feet, bonded to the panel underside; the stepped feet were cored with a vertical pultruded FRP rod. "The quay varies 80 mm [3.2 inches] in height over its surface," he points out. "We needed to be virtually level with the crane rail to eliminate any trip hazard, so we bonded GFRP shims to the stepped feet to keep the panels level," he adds.

Some panels required cutting to accommodate the quay bollards (thick, yellow curved posts in photos), and in other panels, openings were cut and fitted with hinged lids for manhole/fire hydrant access. A 300-mm/12-inch gap was left between the panels adjacent to the crane rail and the panels at the water's edge, to accommodate the crane's electrical cables. A stiff rubber "Panzer" belt covers the gap, and the cranes are fitted with onboard lifters that bend the belt up out of the way as the crane rolls through on the rails (see the middle photo).

The total weight of all the composite panels was just 226 metric tonnes (500,000 lb) — within the quay's weight constraint — and the entire project was completed on schedule and within budget.

"As far as I know, this is the first time a project of this type has ever been undertaken in the world," concludes Blyth. "And I believe it was also the biggest single composites job ever completed in South Africa."

SEA LION EXHIBIT | Pultrusions renew seaside aquatic show venue

Source | Strongwell

When Hurricane Sandy devastated the New Jersey and New York City coastline in the U.S., one of the many damaged areas was the Wildlife Conservation Society's New York Aquarium. The Aquarium's storm-ravaged Aqua Theater, which featured bleach-er seats and a wooden walkway, was redesigned and rebuilt to showcase the facility's popular sea lions. Engineering firm Dunne & Markis Consulting (Riverdale, N.Y.) worked with Harrington Industrial Plastics (Chino, Calif.) to find a durable material that would stand up to corrosion, because the exhibit's centerpiece is a pair of saltwater pools *and* it is located on Coney Island's Atlantic shore in Brooklyn, N.Y. (The oceanfront is visible from the bleachers, see top photo).

Harrington worked with pultruder **Strongwell Corp**. (Bristol, Va.) and selected Strongwell's EXTREN pultruded fiberglass/polyester structural support profiles, including angles, plates and I-beams, to support its trademarked DURADEK pultruded I-6000 fiberglass/vinyl ester grating. These composite components were used to create new audience seating and standing areas as well an irregular, decorative pool edge. The edging, mounted at different levels, provides platforms (lower photo) onto which sea lions can pull themselves from the water, and was designed to support their weight, which can range up to 500 lb/227 kg each.

Zoo officials are pleased with the remodel, which should provide many years of service. The project received a 2013 Merit Award from the publication *Engineering News-Record* (*ENR*) in the Sports/Entertainment category.

Calendar

APRIL

April 8-10, 2014 **Composites Manufacturing 2014**
Covington, Ky. | Composites.sme.org/2014/public/enter.aspx

April 15-16, 2014 **High Performance Polymers for Oil and Gas 2014**
Edinburgh, U.K. | www.oilgasconference.com/home.aspx

MAY

May 5-8, 2014 **Windpower 2014**
Las Vegas, Nev. | www.windpowerexpo.org

May 13-15, 2014 **JEC Americas/Techtextil North America/Texprocess Americas**
Atlanta, Ga. | www.jeccomposites.com; www.techtextilNA.com

JUNE

June 2-5, 2014 **SAMPE Tech 2014**
Seattle, Wash. | www.sampe.org/events

June 2-6, 2014 **MCM-2014, the XVIII Int'l Conference on Mechanics of Composite Materials**
Riga, Latvia | www.pmi.lv/New/EnConferenceAbout.html

June 8-11, 2014 **1st Int'l Conference on Mechanics of Composites (MECHCOMP2014)**
Atlanta, Ga. | https://sites.google.com/site/mechcomp2014/

JUNE

June 10-11, 2014 **SAE 2014 Design, Manufacturing and Economics of Composites Symposium**
Madrid, Spain | www.sae.org/events/dtmc

June 11-12, 2014 CW **CompositesWorld's Thermoplastics for Automotive Applications Conference/ameri*mold* 2014**
Novi, Mich. | http://www.amerimoldexpo.com/zones/track-info?alias=thermoplastic-composites-for-automotive

SEPT

Sept. 8-14, 2014 CW **IMTS 2014: TRAM – Trends in Advanced Machining, Materials and Manufacturing**
Chicago, Ill. | www.tram-conference.com

Sept. 9-11, 2014 **SPE's Automotive Composites Conference and Exhibition (ACCE)**
Novi, Mich. | http://speautomotive.com/comp.htm

Sept. 30-Oct. 2, 2014 **IBEX 2014**
Tampa, Fla. | www.ibexshow.com

OCT

Oct. 13-16, 2014 **CAMX – The Composites and Advanced Materials Expo**
Orlando, Fla. | www.thecamx.org

Oct. 27-29, 2014 **SAMPE China 2014**
Beijing, China | www.sampe.org.cn

NEW Products

Early highlights from JEC Europe 2014

Closed molding consumables

Airtech International (Huntington Beach, Calif.) introduced two extruded fluoropolymer films. The first, Wrightlease 2R, is coated with a rubber-based pressure-sensitive adhesive. Its light-green color is visible on most substrates. Benefits include multiple releases from all common resin systems; good adhesion to metals, composites, tooling blocks and rubber

tooling; and high elongation and strength to ensure coverage of complex contoured surfaces. The second, Toolwright 3 (photo above), is coated with a silicone pressure-sensitive adhesive and is thinner and, therefore, more easily applied over complex contours than Toolwright 5. Toolwright 3 offers not only high elongation and strength but high-temperature resistance and easy cleanup after removal. Benefits include extended tool life, tear resistance, fast application, and improved part surface quality.

Also on offer: Airseal 2 sealant tape, reformulated to improve tack, feel, and cleanup and to extend its shelf life. Designed for room- and medium-high-temperature applications, it also can be used in vacuum-bag applications that process at higher temperatures. Airseal 2 Tacky is a softer version, with better tack in colder environments.

Also reformulated, Airpad HTX (photo at left) reportedly performs better than competing rubber caul-sheet materials. Benefits include low shrinkage, dimensional stability, good bonding to reinforcing layers and surfacing release films, aggressive self-bonding for easier repairs, high Shore hardness for better pressure intensification, and good solvent resistance.

Lastly, the company's Airflex uncured silicone rubber has been formulated for use as a pressure intensifier on complex shapes during vacuum bagging. It also can be used to protect vacuum bags from puncture due to bolt heads. **www.airtechonline.com**

Epoxy for HP-RTM processes

Dow Automotive (Horgen, Switzerland) touted its new Dow VORAFORCE 5300 epoxy resin matrix system for high-pressure resin transfer molding (HP-RTM) and its variants. Dow officials say the formulation offers low viscosity to enable resin transfer yet also cures quickly. Also new was Dow's VORAFORCE TW 1100 series of polyurethane systems, developed for filament winding, particularly in the case of power and transmission poles. Dow also presented a new development in its AIRSTONE family, targeted to customers in the wind-energy industry. The new Dow AIRSTONE 87 system offers a series of high-elongation adhesives. **www.dow.com**

Nonhalogenated flame retardants

Clariant (Muttenz, Switzerland) highlighted the advantages of its nonhalongenated, phosphinate-based Exolit OP range and Exolit AP range of flame retardants for transportation and construction applications. Designed initially for the electronics and electrical equipment markets, the Exolit OP range is said to offer high thermal stability and good property profiles at comparably low doses in transport applications, such as railway rolling stock and airplanes. The Exolit AP range, based on ammonium polyphosphate, is formulated for use in thermoset resins that form the matrices in fiberglass-reinforced composites. Reportedly, all are fully compliant with current WEEE and RoHS regulations. **www.clariant.com**

HP-RTM resin metering system

Hennecke GmbH (Sankt Augustin, Germany) introduced its STREAMLINE high-pressure resin transfer molding (HP-RTM) metering system for polyurethane, epoxy and reactive thermoplastics molding. It features what Hennecke calls an "intelligent" filling process with closed-loop control, as well as a high-pressure metering system that includes sensor equipment capable of monitoring internal mold pressure. The closed-loop control system uses the mold sensor to control and manage the resin injection cycle. If the mold is not sensor-equipped, STREAMLINE offers control via machine-internal sensors. The system includes one of three new high-pressure mixheads, which offer options for internal mold-release integration and back-pressure control. Hennecke also offers tutorials on RTM mold manufacturing, mixhead positioning and other basics of the RTM process. **www.hennecke.com**

New automotive production capacity

FORMAX (Leicester, U.K.), a manufacturer of carbon fiber and specialty composite reinforcements, announced plans to open an automotive production facility alongside the company's U.K. headquarters. The new site will be dedicated to weaving and assembling specialized carbon fiber multiaxial fabrics, designed specifically to meet the requirements of high-volume automotive applications. This latest investment and the subsequent site expansion follows FORMAX's recent launch of a number of new automotive textiles. These include aFORM, a specialized ±45° material that ranges in weight from 150 to 300 g/m^2, for Class A surface finishes; reFORM, a recycled materials range produced from carbon fiber waste; and a specialized drape simulation software that enables customers to optimize their fabrics' performance by identifying issues that result from creasing and permeability. **www.formax.co.uk**

Lightweight, machinable, near-zero CTE tooling material

The Hanson Group (Alpharetta, Ga.) introduced MONOCEROS lightweight structural material (pat. pend.), specifically designed to function as either an economical tooling surface or a lightweight structural core (4 lb/ft^3). Porous yet dimensionally stable, it is fire-retardant and is chemical-resistant. As a lightweight tooling medium, 1.5-inch/38-mm thick MONOCEROS sheets can be bonded together, using epoxy or urethane contact adhesives, and, after application of commercially available surfacing putties and pastes or sprayable coatings, are easily machined. MONOCEROS enables rapid heating and cooling of the tool surface and offers high-temperature stability (350°F/177°C maximum, 250°F/121°C continuous), with a negligible coefficient of thermal expansion (CTE). This material is reportedly economical at $3.50/board ft and is available in standard 4-ft by 6.5-ft (approximately 1.2m by 2m) sheets. Custom sizes are available, prebonded by special order, in sizes up to 40 ft long by 6.5 ft wide by 7 ft thick (12.2m by 2m by 2.1m). **www.hansonco.net/monoceros.net**

Adhesive with reduced bondline read-through

Adhesives specialist **SCIGRIP** (Washington, U.K.) launched an enhanced methyl methacrylate (MMA) adhesive. The new MMA product line provides customers the opportunity to select from a greater number of materials and permits bonding of thinner substrates without unsightly read-through lines and distortions on the part's outer skin. It reportedly will appeal to manufacturers of composite structures in the marine and transport markets who are looking to improve the aesthetics of their components while optimizing design, production speeds and part costs. This adhesive reportedly demonstrates low heat distortion and low chemical shrinkage with fast but controllable cure speeds. SCIGRIP also introduced a range of specialized engineering adhesives. **www.scigrip.com**

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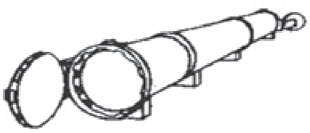

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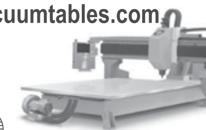

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Composites the clear choice in TELECOM TOWER REHABS

New-tower permitting difficulties spur repairs/upgrades of aging steel structures.

More than 100,000 cellphone towers dot the landscape in the U.S. alone. Millions of people depend on their electromagnetic signals every day for communications, and estimates of the need for additional transmission capacity in the next decade run as high as *five times* the current capacity. However, no one wants a cell tower in their neighborhood. This "not in my back yard" attitude means that operators can't easily erect new towers. Further, existing steel towers are aging and many are now in need of repair. Tower operators must not only repair towers to extend their service lives, but also strengthen them to carry new equipment as demand goes up among cell phone providers.

Repairs and upgrades, however, involve great risk. Galvanized steel towers support miles of flammable coaxial cables. When workers weld steel jackets or additional structural support high onto the existing structure, welding sparks and slag can ignite the cables, resulting in expensive fires. Plus, scaling the towers for any reason is hazardous, even deadly; many climbers have died in tower accidents.

Structural engineer Jim Lockwood, CEO of Comptek Structural Composites (Boulder, Colo.), knew there was a better way: "A telecommunications company saw an article I had written for the American Composites Manufacturers Assn. Market Development Alliance [now the Composites Growth Initiative], and contacted me. That was our opportunity to introduce composites for the tower repair market." Twelve years later, Comptek and its spin-off design/build company, Aero Solutions LLC, have the corner on this specialized and successful market.

FROM MONOPOLES TO GUYED TOWERS

At first, Lockwood's customers wanted a way to increase marginally the structural capacity of galvanized steel monopole towers, which are located, for the most part, in urban locations. The monopoles, hollow steel tubes up to 200 ft/61.5m tall, range from 3 to 5 ft (0.9m to 1.5m) in diameter. Comptek's solution was to bond to the tower a precured pultruded carbon fiber laminate, using structural adhesive. Laminate locations were identified by modeling (described below). This eliminated the risk of igniting the heavy coaxial cables inside the pole and increased tower load capacity, which allowed tower operators to install additional cell phone transmission equipment. But as the work evolved over several years, and as customers demanded much greater structural capacities on their towers — an additional 50 to as much as 100 percent — the laminates had to be thicker, which added considerable cost due to the high volume of carbon needed to achieve the necessary stiffness. Today, Aero Solutions deploys carbon fiber solutions teamed with bolted-on steel plate, he relates, when the higher capacity is required.

Increasing the structural capacity of taller "guyed towers," however, demanded a different approach. Usually erected in suburban locations, these skeletal structures (see photos, this page) fea-

Sources (left to right) | CG Engineering / Comptek Structural Composites

The unsettling view down from a guyed steel telecom tower in need of repairs to halt corrosion and add structural capacity for ever-increasing cellphone equipment installations. Exposed coaxial cables present a fire hazard during welded repairs, but aerial workers (see inset) equipped with Comptek Structural Composites' (Boulder, Colo.) composite materials can perform rehabilitations with greater ease and safety (prepreg wraps are visible in white, and a carbon half-shell is visible on the center tower leg).

COMPTEK STRUCTURAL COMPOSITES' GUYED TELECOMMUNICATIONS TOWER REINFORCEMENT

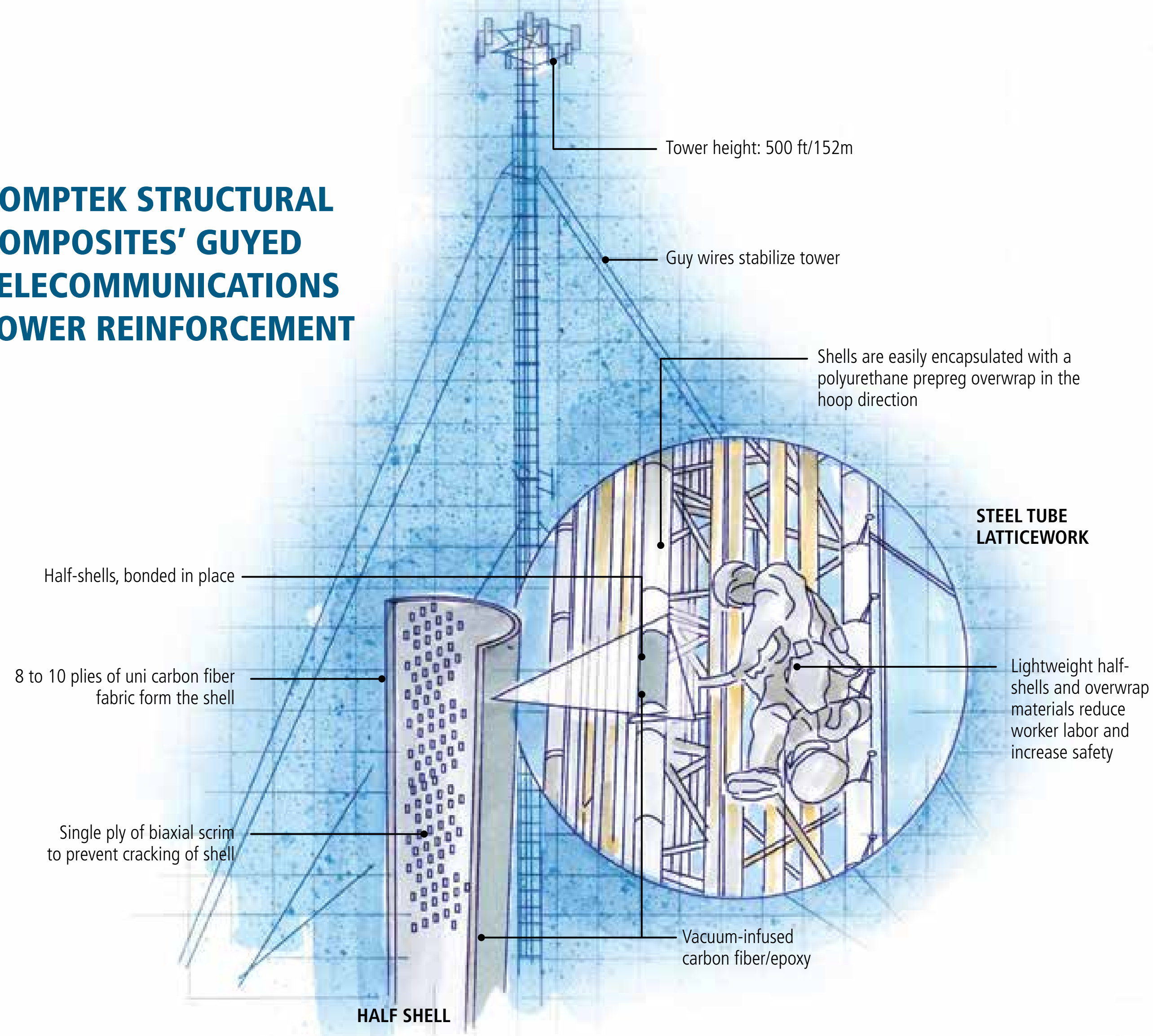


Illustration | Karl Reque

ENGINEERING CHALLENGE:

Heavy antenna equipment, metal materials and flammable cabling on aging steel telecommunications towers spell hazardous duty for workers who must climb them and make welded repairs.

DESIGN SOLUTION:

Lightweight, prefabricated carbon fiber composite shells that can be quickly and easily bonded and hoop-wrapped at any height on a tower to repair or add structural capacity for additional antennae.

ture slender steel-tube latticework that can soar to heights of 500 ft/154m, kept in place by guy cables. For guyed tower leg applications, Lockwood envisioned lightweight, vacuum-molded carbon fiber half shells to replace conventional split steel pipes that had to be welded onto the slender legs. The cured half shells would weigh only a few pounds and, therefore, could be carried easily by technicians as they climbed the towers, and then quickly bonded around a tower leg, eliminating the need for welding — all of which would enhance installation safety. The precured half-shells also proved to be a reliable *repair* solution for the steel legs, which can split over time due to freeze/thaw cycles when water enters weep holes. "Engineers at a very large U.S. tower company, Crown Castle [Houston, Texas], understood composites and adhesives, and what they could do for strengthening and repair, and really became a composites 'champion' for the tower industry and our approach," Lockwood says.

CUSTOMIZED FOR COMPRESSIVE MODULUS

The primary load on guyed towers, as on monopoles, is wind load, which tends to cause buckling of the tall, thin structural legs. To add structural capacity, then, the carbon fibers must be aligned parallel to the steel legs, and the compressive modulus of the fiber and resin is the key design factor. Lockwood decided to precure a unidirectional laminate shell under controlled conditions to ensure consistent modulus. He designed a simple aluminum shell mold, in a half-pipe shape, and custom-molded carbon composite shells, approximately 20 ft/6.2m long, and 5 inches/125 mm edge to edge.

Actual half-pipe dimensions are customized for each tower. The shells are made with 8 to 10 plies of 9-oz unidirectional carbon fiber fabric supplied by Zoltek Corp. (St. Louis, Mo.) and several other suppliers. A single ply of biaxial scrim is the last ply down, adding off-angle fibers to support and strengthen the unidirectional fibers. The ►

Cured carbon fiber half shells are shown in Comptek's workroom. Note the solid aluminum billet mandrel mold, in a half-pipe shape, extending underneath the shell at far left. Parts are molded using 8 to 10 plies of unidirectional carbon fiber fabric, with one additional ply of carbon fiber biaxial scrim that lends support to the shell during handling.

Comptek's proprietary E-glass/polyurethane prepreg overwrap material is made in-house and stored in vacuum-sealed bags (in photo background). The overwrap not only protects the carbon repair, but also provides a smooth, paintable surface that can stand up to future equipment installations. A sample wrapped section is shown in the foreground. The prepreg has spawned a side business called BolderBond (see sidebar, lower left).

scrim prevents "pinching" or other damage during transport. The lay-up is then bagged, and infused with a toughened epoxy resin supplied by Gurit (USA) Inc. (Bristol, R.I.), and cured at room temperature.

On the tower, two shells are bonded together to enclose target sections of the tower leg using a structural epoxy adhesive fortified with thermoplastic fibers to minimize dripping. The epoxy bond line isolates the carbon from the steel tower, eliminating any galvanic corrosion, explains Lockwood. The final step is to hoop-wrap the joined carbon shells with a one-part, water-activated, polyurethane prepreg overwrap, developed inhouse by Comptek.

To prepare the proprietary wrap, E-glass fabric is prepregged at Comptek's facility in a humidity-controlled room with the water-activated polyurethane resin, which contains an additive to inhibit ultraviolet degradation. The prepreg is cut and kitted and placed inside a vacuum-sealed bag for transport to the site. After the technician applies the wrap, he simply sprays it with water to initiate cure. The tough overwrap is designed to protect the uni carbon from damage during future equipment installations, and its surface is easily painted in the white/red color scheme mandated by the Federal Aviation Admin. "The prepreg provides full confinement to the shells," Lockwood points out. "And it's durable enough to withstand the clamping force of any future antenna brackets." It also gives the repair a smooth, low-profile and aerodynamic surface, which cuts wind load — the inspiration, he notes, for the name Aero Solutions.

COMPTEK'S CONSUMER ADHESIVE SPIN-OFF

When technicians involved in Aero Solutions LLC's repair projects reported that resin residue left in the bags that contained the company's glass/polyurethane protective wraps was "great for gluing stuff," Comptek Structural Composites' CEO Jim Lockwood decided to try bottling it. The resin, minus its UV inhibitor, is now marketed under the name "Bolder Bond," a take-off on Comptek's Boulder location. Reportedly similar to Gorilla Glue and other consumer adhesives, but with less tendency to expand during the cure cycle, the product has seen successful sales through a distributor, Lockwood claims, and is available in Colorado-area retail hardware stores. More information is available at www.bolderbond.com.

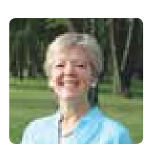
GAME-CHANGING DESIGN

To determine exactly *where* to apply the shells on a tower, a structural analysis is required, typically using *tnxTower* software from Tower Numerics (Lexington, Mass.), a common design tool for telecom towers. Aero Solutions applies its proprietary inhouse post-processing software, called AeroSoft, to the *tnxTower* program, to optimize shell placement. "This stiffness-based program tells us, for instance, where the tower is overstressed if a new antenna is going to be installed at the 200-ft [61m] level," he explains. "The exact location is based on the new equipment and cabling, as well as any observed deterioration."

The Comptek material solutions implemented by Aero Solutions reportedly have changed the landscape for tower operators. All the materials for a repair job can be transported to a project site in a pickup truck, and climbers can complete a major rehab in as little as one day — a far cry from the time necessary for steel-centric solutions. And, says Lockwood, "We've developed a carbon wrap system for repairing monopole tower *foundations*, where strengthening and repair is often needed. When more steel rods are drilled down into the existing caisson, cracks can occur, which the wrap addresses."

For Lockwood, the outlook is positive, not only in tower rehab but other markets. "There is a lot of room for composite product development for infrastructure repair," he points out, adding, "I started this company to create innovative repair solutions for oil and gas pipelines, for refineries, for bridges, and so much more."

"The tower repair niche is a niche that makes you think of other niches!" he quips. | CT |



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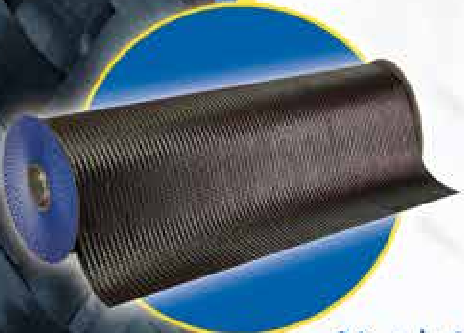
F A B R I C S

by A&P Technology

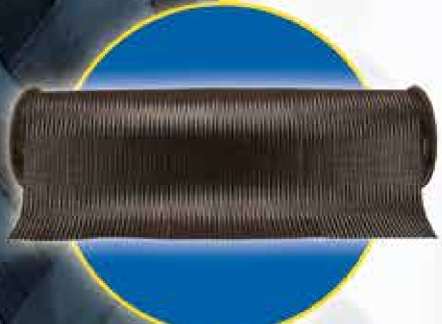


QISO™

Brand Braided Triaxial Fabric

0°, +/- 60° single layer balanced lamina.

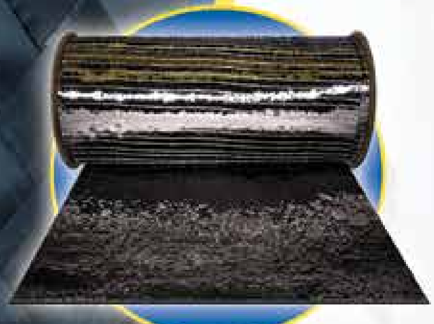
QISO™ has equal amounts of material by weight in every direction providing equal properties regardless of ply orientation.



BimaX™

Brand Braided Bias Fabric

*Bimax™ biaxial fabric offers a **+/- 45° fiber orientation** without cutting, stitching or manipulation.*



ZERO™

The ultimate zero degree reinforcement

*ZERO™ is a **non-woven unidirectional fabric** with virtually no crimp in the reinforcement fibers. ZERO™ is highly efficient and very affordable. ZERO™ is also offered in a heavy duty form – Quilted ZERO™. Quilted ZERO™ provides a higher areal weight for building thickness and withstands tough handling.*

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