CompositesWorld.com

CompositesWorld

Aeris Energy: BRAZIL'S WIND BLADE EPICENTER

MARCH 2017

DOWNLOAD this issue of *CompositesWorld* in a low-res PDF format
— CLICK HERE —


Accelerate Composite Production
Revving up production and speed-to-market starts with composite solutions that reduce cycle times. Hexion EPIKOTE™ resin systems include fast cure options backed by expertise in RTM, LCM and SMC processing, to drive your innovation.
Learn how you can fast-track award-winning components at:
hexion.com/epoxyphenoliccomposites
Visit us at
JEC Composites 2017
Booth #G54
March 14–16 Paris, France
HEXION™
Helping you make it in today's world.
© 2017 Hexion Inc. All rights reserved. ® and ™ denote trademarks owned by or licensed to Hexion Inc.

MARCH 2017 / Vol: 3 Nº: 3

COLUMNS

FEATURES

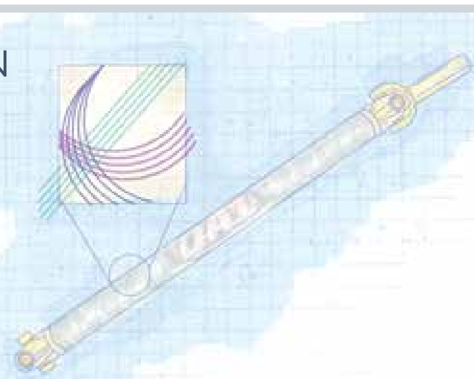
» DEPARTMENTS

» ON THE COVER

Brazil's electric power industry was built on hydroelectric power. But during droughts, water flow and energy generation suffer. During a drought, the stiff winds in the Brazil's northeast region are actually stronger. This has spawned a wind energy sector complementary to hydropower, of which Aeris Energy (Caucaia, Brazil) is a key part. *CW* recently toured its facility (see p. 36).

Source / Wellington Fernandes

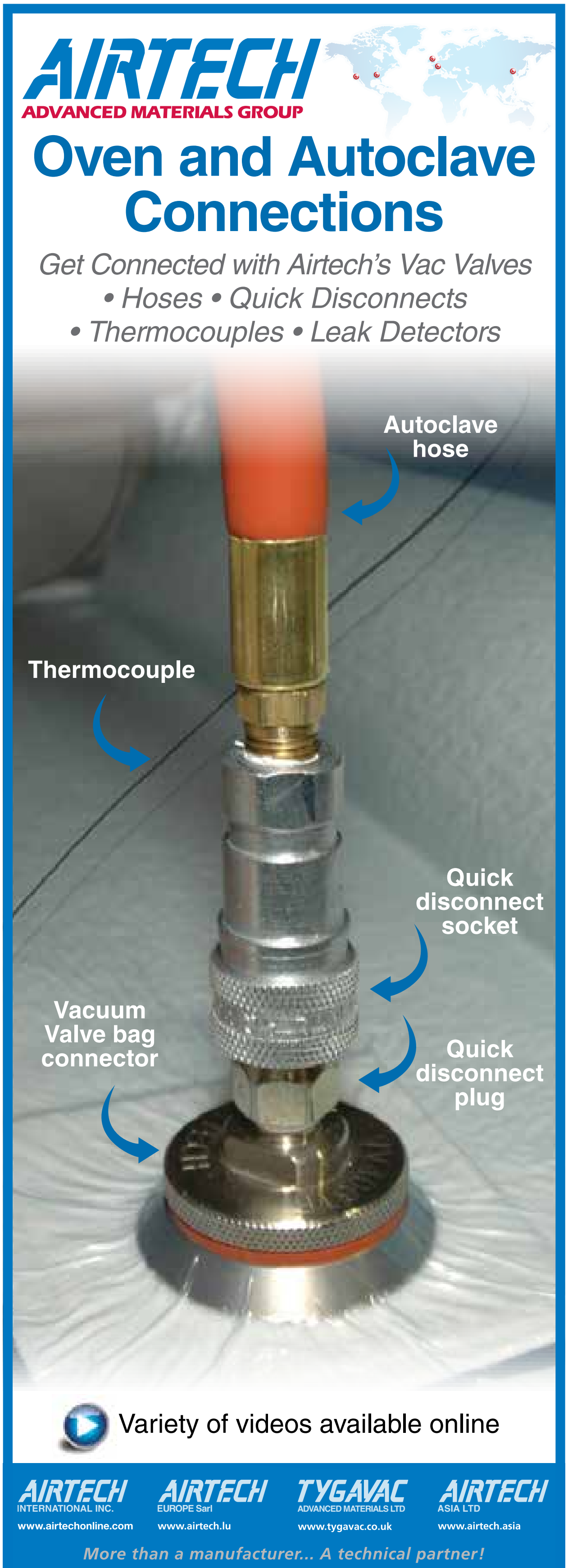
FOCUS ON DESIGN



CompositesWorld (ISSN 2376-5232) is published monthly and copyright © 2017 by Gardner Business Media Inc. 6915 Valley Ave., Cincinnati, OH 45244-3029. Telephone: (513) 527-8800. Printed in U.S.A. Periodicals postage paid at Cincinnati, OH and additional mailing offices. All rights reserved. POSTMASTER: Send address changes to *CompositesWorld* Magazine, 6915 Valley Ave., Cincinnati, OH 45244-3029. If undeliverable, send Form 3579. CANADA POST: Canada Returns to be sent to IMEX Global Solutions, PO Box 25542, London, ON N6C 6B2 Canada. Publications Mail Agreement #40612608.

The information presented in this edition of *CompositesWorld* is believed to be accurate. In applying recommendations, however, you should exercise care and normal precautions to prevent personal injury and damage to facilities or products. In no case can the authors or the publisher accept responsibility for personal injury or damages which may occur in working with methods and/or materials presented herein, nor can the publisher assume responsibility for the validity of claims or performance of items appearing in editorial presentations or advertisements in this publication. Contact information is provided to enable interested parties to conduct further inquiry into specific products or services.

MEMBERSHIPS:



CW
CompositesWorld

CompositesWorld.com @CompositesWrld

PUBLISHER Ryan Delahanty
rdelahanty@gardnerweb.com

EDITOR-IN-CHIEF Jeff Sloan
jeff@compositesworld.com

MANAGING EDITOR Mike Musselman
mike@compositesworld.com

SENIOR EDITOR Sara Black
sara@compositesworld.com

SENIOR EDITOR Ginger Gardiner
ggardiner@compositesworld.com

DIGITAL MANAGING EDITOR Heather Caliendo
hcaliendo@gardnerweb.com

GRAPHIC DESIGNER Susan Kraus
skraus@gardnerweb.com

MARKETING MANAGER Kimberly A. Hoodin
kim@compositesworld.com

CW CONTRIBUTING WRITERS

Dale Brosius dale@compositesworld.com
Donna Dawson donna@compositesworld.com
Michael LeGault mlegault@compositesworld.com
Peggy Malnati peggy@compositesworld.com
Karen Wood kwood@compositesworld.com

CW SALES GROUP

MIDWESTERN US & INTERNATIONAL Ryan Mahoney / DISTRICT MANAGER
rmahoney@compositesworld.com

EASTERN US SALES OFFICE Barbara Businger / DISTRICT MANAGER
barb@compositesworld.com

MOUNTAIN, SOUTHWEST & WESTERN US SALES OFFICE Rick Brandt / DISTRICT MANAGER
rbrandt@gardnerweb.com

EUROPEAN SALES OFFICE Eddie Kania / EUROPEAN SALES MGR.
ekania@btopenworld.com

COMPOSITESWORLD IS A PROPERTY OF

GARDNER Business Media, Inc.

HEADQUARTERS
6915 Valley Ave., Cincinnati, OH 45244-3029
Phone 513-527-8800 Fax 513-527-8801
gardnerweb.com
subscribe@compositesworld.com

CHAIRMAN & CEO Rick Kline, CBC
COO Melissa Kline Skavlem
PRESIDENT Rick Kline, Jr.
SENIOR VP, CONTENT Tom Beard
DIRECTOR OF MARKET INTELLIGENCE Steve Kline, Jr.
TREASURER Ernie Brubaker
ADVERTISING MANAGER Bill Caldwell
DIRECTOR OF EDITORIAL OPERATIONS Kate Hand
DIRECTOR OF MARKETING AND EVENTS Dave Necessary
CREATIVE DEPARTMENT MANAGER Rhonda Weaver
CREATIVE DIRECTOR Jeff Norgord
ADVERTISING PRODUCTION MANAGER Becky Helton

GARDNER BUSINESS MEDIA ALSO PUBLISHES

Modern Machine Shop
Moldmaking Technology
Plastics Technology
Automotive Design & Production
Production Machining
Products Finishing
Additive Manufacturing

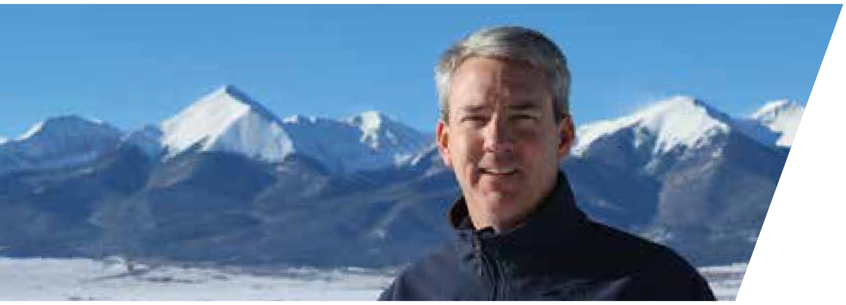
Working with Composites One is a unique partnership with our **PEOPLE**. From regional customer service reps and technical sales teams, to local support teams at over 35 distribution centers in the U.S. and throughout Canada, we'll make sure you find what you need, and receive it when you need it. As your partner, we'll give you access to emerging market expertise and process application know-how, and do what it takes to help grow your business. We'll also provide you with the unmatched service and support you should expect from North America's leading composites distributor.

That's the power of Partnership. The Power of One – Composites One.

COMPOSITES ONE®

800.621.8003 | www.compositesone.com | www.b2bcomposites.com

Visit compositesone.com



Autocomposites and the myth of $5/lb carbon fiber.

» When I started this job in September 2006, one of the first "composites truths" handed down to me from on high was this: Carbon fiber will not be applied to high-volume automotive structures until and unless the unit cost of said carbon fiber drops to or below US$5/lb.

And if you ask any 10 composites industry veterans what the origin of this "truth" was, you will almost certainly get 10 different answers, ranging from the plausible — "Ford Motor Co. said it in a meeting with material suppliers in 1988" — to the fantastic — "It was Richard Nixon's deathbed proclamation." (OK, I made that second one up, but you get the point.)

Anyhow, regardless of the genesis of this statement, it has been repeated so frequently in the ensuing years that it has assumed the veneer and polish of fact, often pulled out and pointed to by automotive OEMs whenever the composites industry gets to feeling a little uppity about making automotive inroads. And then we are politely reminded of our place in the materials food chain: "Now remember, little fella," say the OEMs, "we're used to affordable steel. We can't use none of that new-fangled carbon fiber unless it's super-cheap! But if you get the price down to $5/lb — oh boy! That would be something! Now run along ...."

And then, a funny thing happened: Carbon fiber got cheaper. How cheap? It's hard to say. Carbon fiber manufacturers don't publish their prices, but some casual inquiries revealed that 50K tow, industrial-grade carbon fiber can be acquired from one or more suppliers for as little as $7-$8/lb (€15.4-€17.6/kg). This is not $5/lb (yet), but it is also not $12 or $15/lb. And given this downward trajectory, plus the ongoing research into low-cost carbon fiber at Oak Ridge National Laboratory (ORNL, Oak Ridge, TN, US), it's not unreasonable to think that this infamous threshold might be breached soon. And then, oh boy!

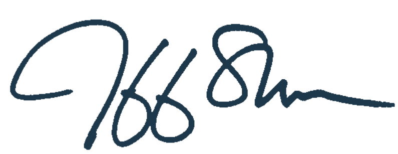
Maybe.

The truth of the $5/lb truth, however, is more complex than it appears. The true truth is that even if carbon fiber were offered to automakers for $0/lb, its use in high-volume automotive structures would not be a foregone conclusion. This is because the $5/lb line in the sand comes with a similar challenge that, ultimately, will determine the fate of carbon fiber in automotive: Manufacturability.

The real Achilles heel of carbon fiber composites manufacturing is that *it's not easy* — at least not easy the way metal stamping and plastic injection molding are. It's not easy to design, not easy to simulate and not easy to manufacture. Carbon fiber composites manufacturing means coping with a far greater number of variables, each of which must be anticipated, measured and then controlled. To top it off, composites are the *only* materials in the world that are made at the *same time* as the parts they make.

This isn't to say that it's not getting easier, because it is. And in the automotive industry, fabrication of carbon fiber structures is focusing on molding processes that mimic legacy metalforming processes: Compression molding, injection overmolding and resin transfer molding show great promise for high-volume autocomposites manufacture, but to activate the value of that still-mythical $5/lb carbon fiber, they must meet automotive supply chain cycle time, repeatability, process control and waste requirements. And of these, the most important might be waste. Composite parts, no matter how inexpensive carbon fiber becomes, will always have a relatively large material cost burden, thus material use must be fully optimized to make carbon fiber viable.

So, the real question for automotive OEMs is not, How cheap do you want your carbon fiber to be? Rather, the question is, What is your cost target per kilogram of part weight? I await the answer from on high — or you. Email me at **jeff@compositesworld.com** with your "true" number.

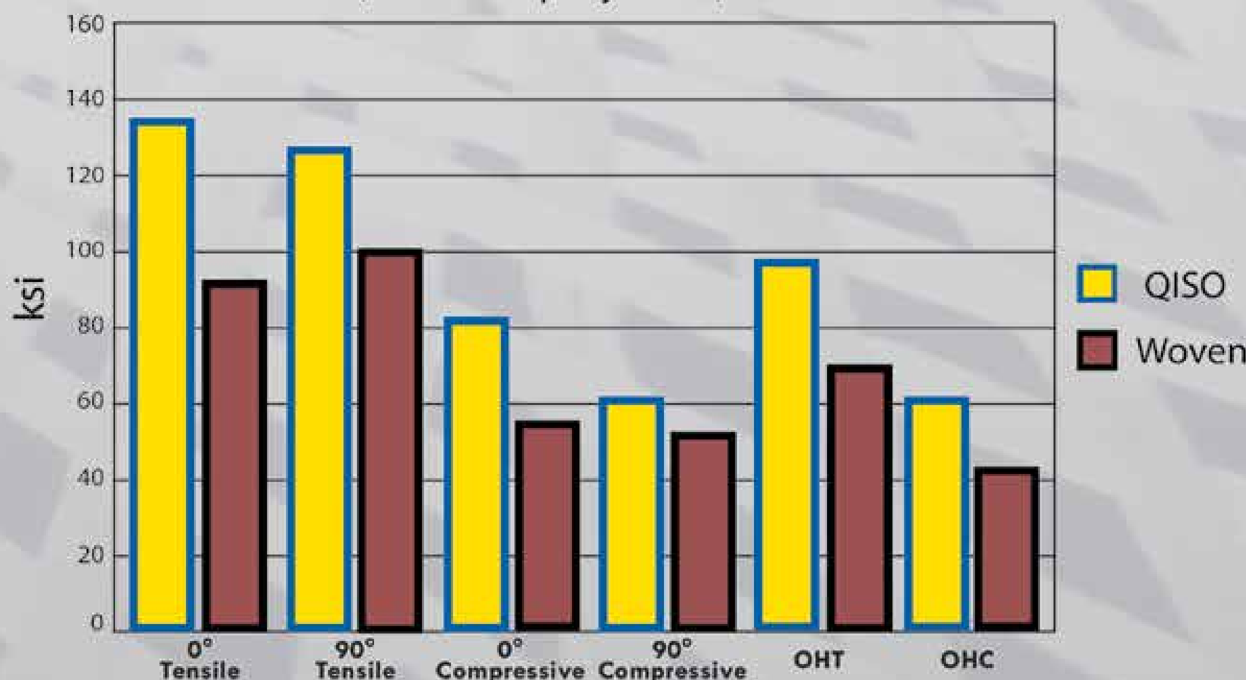


JEFF SLOAN — Editor-In-Chief

QISO™
Quasi-Isotropic Fabric

QISO OUTPERFORMS WOVEN

T700S 12k Fiber, TC275-1 Epoxy Resin, Normalized to 55%



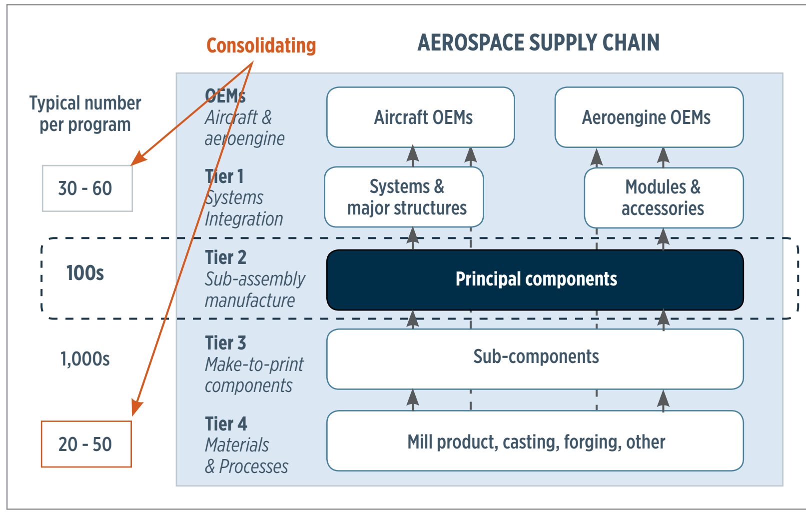
BETTER PARTS
LOWER COST
LET US SHOW YOU HOW

CONTACT US AT
SALES@BRAIDER.COM
513-688-3200 | braider.com

A&P Technology

Aerospace composites in "the more for less" era

» Over the past 10 years, the aerospace industry has been marked by a lot of design innovation and technology introduction, starting with the Airbus (Toulouse, France) A380, and followed by The Boeing Co.'s (Chicago, IL, US) 787 and the Airbus A350. But there are important changes coming. We're entering a new period, one not so focused on the above but instead on a theme of "better, cheaper, faster." The past decade was about innovation; the next will be about productivity, and this change will require different success factors from aerospace suppliers.



Tier 2 suppliers face a squeeze from consolidating Tier 1s and Tier 4s. The clear overabundance of Tier 3 suppliers spells certain attrition on that level of the supply chain. Source | AeroDynamic Advisory

Worldwide aircraft production today, across all market segments, is valued at US$180 billion, and should peak at nearly US$210 billion in the year 2021. A slowdown is likely after that. The good news is that aerospace is and will remain a growth market — it was the only major capital goods industry that grew through the Great Recession. Large jetliners account for more than half of this market value, and the military segment looks to be on a growth trajectory. But I've focused on the commercial air transport market, because this is where the clear majority of aerocomposites are used.

We've been in a very unusual period: An incredibly large number of aircraft orders have been placed over the past few years, and these orders have been driven largely by a combination of high jet fuel prices and the current ultralow cost of capital. Simply put, airlines wanted more efficient aircraft to offset fuel prices, and could afford them. Although jet fuel cost has ebbed since 2012, continuing low interest rates are supporting fleet recapitalization and current aircraft orders. That said, reduced oil prices do impact twin-aisle aircraft, making it less expensive to keep older aircraft flying, which has reduced backlogs for larger twin-aisle planes, such as the 787. The bottom line is that there is currently a record number of orders booked for *single* aisles, including the newer re-engined versions of the Airbus A320 and the Boeing 737. Both Boeing and Airbus want to get to a production rate of 60 single-aisle units per month, because this is where they make their money, given the current weakness in the twin-aisle area.

> The past decade was about innovation and new technology. The next will be about productivity.

The Boeing/Airbus duopoly is, in fact, *dependent* on single-aisle aircraft sales for the vast majority of their profits, which is the motivator for increasing production rates. Yet, the two companies have for years been engaged in a market share competition. As a result, both have offered single-aisle products *below* list prices, so the *realized* prices (what air carrier customers have actually paid) for A320s and 737s have remained virtually unchanged since 2002. Some argue that single aisles have become commodities. The two OEMs are now shifting focus to increasing their profits, to as high as 15-20% margins.

Boeing and Airbus are undertaking initiatives that include growth in higher margin services (aftermarket) revenue, which will include new value propositions and, potentially, acquisitions of service companies. Others include aggressive supplier cost reduction through initiatives like Boeing's "Partnering for Success," plus better labor agreements, more automation and "lean" programs. In aerostructures, OEM tactics will include part redesigns, a move to lower-cost processes, material substitution, tougher commercial contracts and recapturing more scrap. The bottom line is that we're in for a period of extreme focus on *cost*, that is, *reducing* costs to pursue profits. Expect more automotive-style operations and practices.

So, what are the implications for suppliers? Typically, the aerospace supply chain includes 30-60 Tier 1 suppliers that are responsible for systems integration; hundreds of Tier 2 suppliers that make principal components; thousands of Tier 3 suppliers responsible for subcomponents, and perhaps 20 to 50 Tier 4 companies that supply materials and processes (metals and composite prepregs). The OEMs prefer to deal only with Tier 1s, so those firms are the primary targets of OEM supply chain initiatives, and they'll face enormous pressure in terms of pricing and selective customer vertical integration. This will lead to continued »

WISCONSIN OVEN

Your Composite Curing Oven Specialists

Interior Supply and Return Ducts with Interior Lighting

Interior Thermocouple Jack Panel & Vacuum Stubs

Pressure Transducer Monitoring Lines and Data Acquisition Control System

Vacuum Lines for Composite Bag Applications

Vacuum Piping System w/ Pressure Transducer & Thermocouple Jack Panel

ACMA American Composites Manufacturers Association

2675 Main Street • PO Box 873 • East Troy, WI 53120 USA
www.wisoven.com • sales@wisoven.com • 262-642-3938

TPS™ Thermal Product Solutions

Wisconsin Oven is a brand of Thermal Product Solutions, LLC consolidation of Tier 1s in the coming year. Tier 2s, in turn, will face a downward squeeze from consolidating Tier 1s and upward pressure from Tier 4s, and it will be very important for them to develop what I call a "winning business model" and a capacity for competitive differentiation. And, there are far too many Tier 3 firms; attrition is a certainty, and consolidation will take place at this level as well. However, in my opinion, consolidation of Tier 4 suppliers is nearly complete (see the "Aerospace Supply Chain" chart on p. 6).

If we look at aerospace raw material demand, which totaled 1.56 billion lb (707 million kg) in 2015, composites demand accounted for 71 million lb (32.2 million kg), or roughly 5% of the total. I expect that composite material's 5% share of demand will grow by 6% per annum through 2020, with titanium close behind at a 4% annual growth rate. The aggregate "buy-to-fly" ratio is approximately 6:1, for all materials combined. Thanks to design and processing improvements, the composites buy-to-fly ratio is far less, ranging from 1.2:1 to 1.4:1, which helps favor its growth.

Of the aerospace-related events that occurred in 2016, two stand out that appear to validate the contention that changes are coming to this market. Foremost is that Boeing opened its composite wing center in Everett, WA, US. That Boeing brought wing manufacturing back in-house and will keep wing manufacture close to the design process is one big indication that Tier 1s will not have the opportunity to build wings in the future, and will settle for fewer and less-profitable projects. Another was the first delivery of the Bombardier (Montreal, QC, Canada) *CSeries* single-aisle jet, to Swiss Airlines. It features the industry's first aluminum-lithium alloy fuselage, with composite wings made via infusion. Aluminum-lithium is significantly less dense than aluminum alone, yet is more damage tolerant at lower cost than composites. This might signal some significant material changes in single-aisle jets. The composites industry must gird itself for tougher conditions in supplying aerospace components in the coming years. CW

ABOUT THE AUTHOR

Kevin Michaels is president of AeroDynamic Advisory (Ann Arbor, MI, US), a boutique consulting firm focused on the global aerospace and aviation industries. He has 30 years of aviation experience and is a globally recognized expert in the aerospace manufacturing and MRO sectors. He also has significant expertise in business-to-business marketing, customer satisfaction, M&A advisory, technology assessment, cluster development and strategic planning. Michaels is a contributing columnist to *Aviation Week & Space Technology* and serves on the advisory board of the University of Michigan's Aerospace Engineering Department. This column is based on a *CW*-hosted webinar aired in October 2016.

THE COMPOSITES iacmi INSTITUTE

INSTITUTE FOR ADVANCED COMPOSITES MANUFACTURING INNOVATION

Developing innovative technologies in composite manufacturing

CEO
Bryan G. Dods
865.974.8794
bdods@iacmi.org

Technology Area Contacts

VEHICLES
Lawrence Drzal
517.353.5466
drzal@egr.msu.edu

WIND
Derek Berry
303.717.8416
derek.berry@nrel.gov

COMPRESSED GAS STORAGE
Brian Rice
937.229.2519
brian.rice@udri.udayton.edu

DESIGN AND MODELING
Byron Pipes
765.494.5767
bpipes@purdue.edu

MATERIALS
Cliff Eberle
865.574.0302
eberlecc@ornl.gov

IACMI Hosts Fourth Members Meeting in Denver, Colorado

- 300 attendees representing industry, academia and government sectors
- Featured speakers included Colorado Governor John Hickenlooper, Siemens Global, CompositesWorld, Local Motors, DuPont Polymers, The U.S. Department of Energy and more
- Displayed in the lobby was the nine-meter wind blade prototype fabricated in Boulder, Colorado in collaboration with eleven industry partners

What attendees are saying about the event

"The meeting was highly valuable to our organization."

"This is the best place to meet, connect and collaborate with innovators in the field."

"Thanks to The Composites Institute, R&D costs have declined while speed to market with new technology has increased."

Announcements:

- Project proposals may be submitted by IACMI members at any time. ***Visit iacmi.org/projects or contact projects@iacmi.org to learn more.***
- The 2017 IACMI internship program is now open for application submission for short-term and long-term appointments at IACMI partner sites. ***Learn more about internship opportunities at iacmi.org/iacmi-internships.***

Upcoming Events:

- **April 4-5, 2017:** Bryan Dods, IACMI CEO, will be speaking at the ACMA North American Pultrusion Conference in Atlanta, Georgia
- **April 18-19, 2017:** Hands-on workforce training event at the National Wind Technology Center in Boulder, Colorado in partnership with Composites One, Magnum Venus Products and the Closed Mold Alliance
- **May 16-17, 2017:** Hands-on workforce training event at the Vehicles Scale Up Facility in Corktown, Michigan in partnership with Composites One, Magnum Venus Products and the Closed Mold Alliance

Become a member today! iacmi.org/membership

IACMI-The Composites Institute is managed by Collaborative Composite Solutions Corporation (CCS). CCS is a not-for-profit organization established by the University of Tennessee Research Foundation and part of the Manufacturing USA network.

Follow us on twitter @*iacmihq*

In praise of technical service reps

In the 1979 classic movie *Apocalypse Now*, Robert Duvall's character, Colonel Bill Kilgore, exclaims, "I love the smell of napalm in the morning!" In the composites industry, the aromas of styrene, phenolic, methacrylate, molten thermoplastics and other chemicals or polymers are indicators of manufacturing activity. Not everyone appreciates such odors, but owners and general managers of most molding shops will say, "It smells like money." I've heard the same is said on many a livestock farm, so that's probably where the axiom originated. But that's a topic for a different industry magazine!

Sure enough, it's the commercial activity that makes the composites world turn, with lots of limelight shining on industry CEOs, inventors and high-flying sales and marketing personnel. But in this month's column, I want to highlight the role played by technical service personnel. They fly well below the publicity radar, yet without them, incorrect material selections are often made, prototype molding trials fail and manufacturing issues go unresolved.

Tech service representatives: without them, molding trials fail and manufacturing issues go unresolved.

I spent many years in sales and marketing roles in the composites industry, and my technical support people quickly became my best friends. As an engineer, I often knew how to solve the problem at hand, but putting a tech service rep in front of a customer added much greater validity to the outcome.

I was reminded of this value over the past couple of months as the Institute for Advanced Composites Manufacturing Innovation (IACMI, Knoxville, TN, US) was developing a prototype wind turbine blade with several new resins and techniques, to use as a demonstration of some advanced ideas. As a participant in the molding trials, I got to observe, up close, the leverage of previous expertise in doing something different. At Strongwell (Bristol, VA, US), we were pultruding spar caps using a blend of commercial carbon fiber with a novel, low-cost textile PAN carbon fiber produced by Oak Ridge National Laboratory (Knoxville, TN, US). Not only was this the first time anyone had pultruded this new fiber, which has a wide band format, but we also were doing it with a tough polyurethane resin system instead of conventional epoxy. Without the onsite technical support from Huntsman Polyurethanes (The Woodlands, TX, US) and Strongwell, I'm fairly certain we could not have been successful. After clearing a few initial hurdles, the team manufactured the targeted 100m of spar cap for incorporation into the blade.

A month later, a different team of industrial members came together to manufacture the full prototype blade at the National Wind Technology Center near Denver, CO, US. The skins and shear web were produced via vacuum infusion of a novel reactive thermoplastic resin based on methyl methacrylate, called Elium, provided by Arkema (King of Prussia, PA, US). Although we had done some sub-element and subscale trials to better understand the parameters, we were faced with infusing this material through a thick, monolithic root section, then over and under a combination of balsa, foam and the previously pultruded carbon fiber spar caps, surrounded by a thin layer of specially developed glass fabric from Johns Manville (Denver, CO) — to a length of 9m. With dedicated onsite technical support from Arkema, Sika Axson (Madison Heights, MI, US) and Composites One (Arlington Heights, IL, US), we got the layup, bagging and infusion parameters correct, producing a good shear web and both skins on the first trials, without having to remanufacture any of the components. This saved a lot time and enabled us to meet a very aggressive schedule.

One thing that impressed me was how well these industrial partners collaborated and came to agreement about how to process the materials, despite their different experiences, or perhaps, because of these experiences. The *planning* for the molding trials was as important as the actual molding. The skill set of the best technical service people not only includes a deep understanding of materials and processes, but excellent interpersonal and communications skills, especially in front of customers. They also must be road warriors, much like salespeople (but without the pressure of meeting sales forecasts).

While much travel is regional, in an increasingly global composites world, there can also be travel, for weeks, even months at a time, to remote corners of the world where there are no local support offices, the language and customs are different and family is far away. But the key is getting the materials, process or equipment to work, to keep the revenues flowing. These experiences sure make for interesting stories around the dinner table after a long day on the shop floor! I say we should give some added appreciation for the dedication these professionals provide. Without them, progress in this industry would be much slower. CW

ABOUT THE AUTHOR

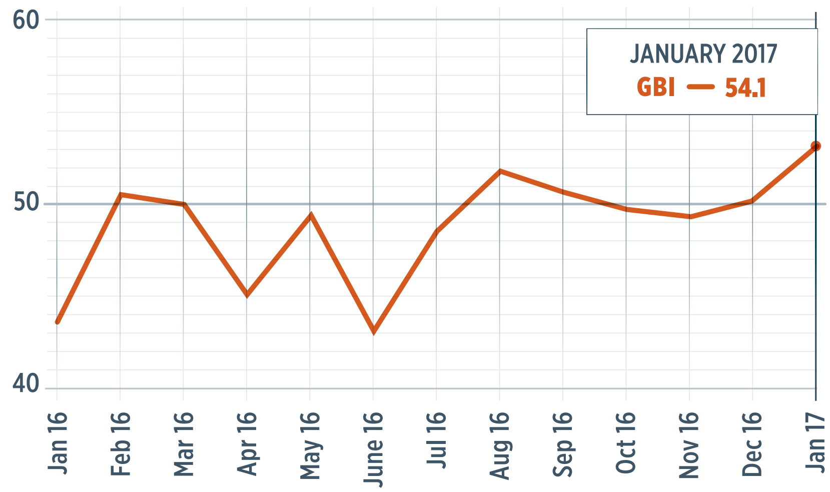
Dale Brosius is the chief commercialization officer for the Institute for Advanced Composites Manufacturing Innovation (IACMI, Knoxville, TN, US), a US Department of Energy (DoE)-sponsored public/private partnership targeting high-volume applications of composites in energy-related industries. He is also head of his own consulting company and his career has included positions at US-based firms Dow Chemical Co. (Midland, MI), Fiberite (Tempe, AZ) and successor Cytec Industries Inc. (Woodland Park, NJ), and Bankstown Airport, NSW, Australia-based Quickstep Holdings. He also served as chair of the Society of Plastics Engineers Composites and Thermoset Divisions. Brosius has a BS in chemical engineering from Texas A&M University and an MBA.


mtorres
At the forefront of technology
ADVANCED COMPOSITE MANUFACTURING EQUIPMENT
JEC world
International Composites Event
Paris, March 14-15-16-2017
HALL 5A / BOOTH P41
www.mtorres.es
Carretera Pamplona-Huesca, Km.9 31119 Torres de Elorz (Navarra) España Tél. +34 948 317 811 Fax +34 948 317 952 info@mtorres.es
www.mtorresamerica.com
21520 30th Drive SE, Suite 210 Bothell, (Washington WA 98021) Seattle, USA Tél. +1 425 984 27 00 Fax +1 425 984 27 35 info@mtorresamerica.com

January 2017 — 54.1

The US composites industry looks as strong as it has since early 2015, with expectations the highest in years.

A GBI reading of >50.0 indicates expansion; values <50.0 indicate contraction.



With a reading of 54.1, the Gardner Business Index showed that the US composites industry grew, in January 2017, for a second straight month. In January, the industry grew at its fastest rate since July 2014. In fact, the Index showed that during the second half of 2016, the industry had performed its best since the first half of 2015. Seen against the backdrop of other economic trends, I think this is a positive sign for the US composites industry in 2017.

New orders grew at an accelerating rate for a second straight month as that subindex reached its highest level since June 2014. The production subindex increased significantly in January. Production grew at its fastest rate since March 2014. Although the backlog subindex continued to contract, it nevertheless had shown general improvement since June 2016. Employment increased for the sixth consecutive month, growing at its fastest rate since a spurt in March 2015. Exports increased in January for the second month in a row. Supplier deliveries lengthened for the second time in three months.

Beginning in April 2016, materials prices increased at a consistently strong rate: That subindex remained slightly below 60 for most of the intervening period. But in January, the rate of materials prices increase went up, reaching its fastest rate since June 2014. Similarly, Prices received increased at an accelerating rate in January, for a third month in a row — this subindex has trended up since January 2016. After a sharp spike in November that coincided with the US elections, and a further bump up in December, the future business expectations subindex decreased slightly in January. However, the subindex was still at its second highest level since GBI survey results were first recorded in December 2011.

Among principal markets served, the aerospace subindex grew for the fifth time in seven months, and the automotive subindex grew for the second month in a row, although the growth rate was minimal in January. Other manufacturing, which includes a lot of miscellaneous consumer goods, grew for the first time since September 2016.

Regionally in the US, the North Central-East experienced the fastest growth for the third time in four months. In January, it grew at its fastest rate since the survey began. The North Central-West grew almost as fast, and experienced upward movement for the third time in five months. The Southeast grew for the second straight month, but the South Central and West, although they posted growth in January, showed upward progress only at marginal rates.

Composites manufacturing facilities with more than 250 employees grew for the third month in a row in January. Plants with 100-249 employees, as January closed out, had posted strong growth for six months. In January, in fact, they grew at their fastest rate since the survey began. Companies with 50-99 employees expanded for the fourth time in five months. After two previous months of moderate contraction, companies with fewer 20-49 employees expanded for the second month in a row. Companies with fewer than 20 employees, however, contracted for a fifth straight month. CW

ABOUT THE AUTHOR

Steve Kline, Jr. is the director of market intelligence for Gardner Business Media Inc. (Cincinnati, OH, US), the publisher of *CompositesWorld* magazine. He began his career 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.
skline2@gardnerweb.com

Images courtesy of Robot Bike Co.

Joining Composites. Refined.

Altair helped Robot Bike Co. combine carbon fiber and 3D printing technologies to develop a fully customizable, lightweight, and high strength mountain bike. We teamed up with HiETA Technologies and Renishaw to make a ground-breaking entry to the market using the very latest design and manufacturing techniques.

We ask you to not just design something. We ask you to DESIGN THE DIFFERENCE™

altair.com/robotbike

Altair
INNOVATION INTELLIGENCE®

Hydraulic-powered hybrid vehicles prove effective, ACMA Executive Forum gauges Trump effect on composites, supplier investments take effect in oil and gas market.

AUTOMOTIVE

Hydraulic hybrids boost fuel economy without batteries

A hybrid vehicle uses two or more power sources, typically gasoline supplemented by batteries and/or regenerative braking. This reduces power demand on the engine, which reduces fuel consumption and emissions. However, a hybrid vehicle does not necessarily have to involve batteries or electrification.

The US Environmental Protection Agency's (EPA, Washington, DC) own investigation tends to support Lightning Hybrids' (Loveland, CO, US) contention that *hydraulic* hybrids are more efficient and easier to implement, especially as heavier vehicles. The EPA has been experimenting with the technology since the late 1980s, and the United Parcel Service (UPS, Atlanta, GA, US) recently added 50 vehicles, using Lightning Hybrids' patented Energy Recovery System (ERS) to its fleet in the Chicago metropolitan area.

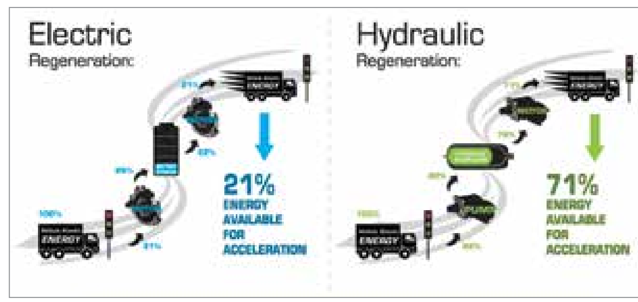
Lightning Hybrids CEO Tim Reeser says his customers report a 15-55% reduction in fuel use and CO_2 emissions and a 50% cut in NOX emissions. Other benefits include:

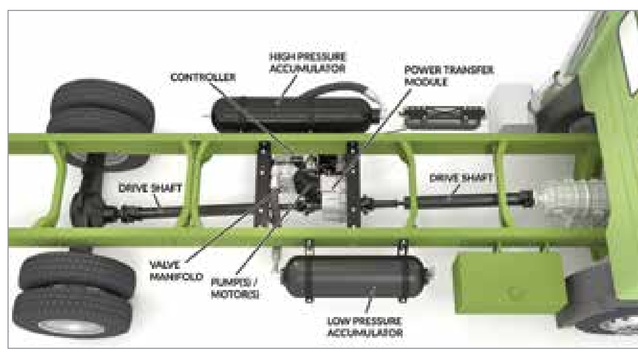
- Requires less space and payload sacrifice vs. battery hybrids;
- Much less expensive than electric hybrid drivetrains;
- Reduces engine exhaust during acceleration;
- Adds power/torque (e.g., 600-800 ft-lb) enabling engine downsizing;
- 100% or better improvement in brake component life.

The systems are reportedly easy to install, fitting between the frame rails towards the center of the vehicle (see photo). Ultimate cost can be reduced to as little as US$5,000 by means of alternative-energy and clean-air grants. UPS, for one, anticipates for its Chicago hydraulic hybrid fleet a return on investment within a short 1-2 year period.

Instead of batteries, hydraulic hybrids use a lightweight hydraulic system comprising a low-pressure reservoir (aluminum tank with bladder) for storing hydraulic fluid (nonflammable) and a pump to move the fluid from the reservoir to a high-pressure accumulator (composite tank with bladder). This accumulator holds not only the fluid brought over by the pump but also pressurized nitrogen gas in the bladder.

During regenerative braking, kinetic energy from the vehicle's motion powers the pump via the driveshaft, moving fluid from the reservoir to the accumulator. This slows the vehicle — the hybrid system acts as the primary braking system. During this phase, pressure builds in the accumulator as the nitrogen gas is compressed: This functions like a mechanical battery, storing energy to be released when the vehicle needs to accelerate again. As the vehicle accelerates, the accumulator sends its energy, in the form of pressurized hydraulic fluid, to the pump, which now acts as a motor, turning the vehicle's driveshaft and, thereby, reducing the load on the engine. As the vehicle accelerates, the hydraulic fluid returns to the reservoir, ready to charge the accumulator again, during the next braking event (see endnote).





Source (both photos) | Lightning Hybrids

Composites play a key role in Lightning Hybrids' ERS high-pressure accumulators. These are Type 3 pressure vessels made by Steelhead Composites (Golden, CO, US). "Accumulators are one of the most ubiquitous components in hydraulics, yet little is known about them," says Mateo Cantu, business development head for Steelhead Composites. For example, accumulators are used to change the pitch of wind blades in turbines > 3MW, to actuate ship rudders and stabilizers, to move aircraft flight controls, landing gear and thrust reversers *(continued on page 16)*

LOW COST CARBON FIBER IS ALREADY HERE!

ZOLTEK
Toray Group

Zoltek has 20,000 tons of industrial grade carbon fiber waiting for *your* automotive business.

Visit www.zoltek.com/automotive to learn more.

(continued from page 14)

and they enable lifting, grading and other operations in heavy equipment like front-end loaders, bulldozers, excavators and combines.

Steelhead Composites' patented carbon fiber/epoxy-wrapped, aluminum-lined accumulators cut weight 66-75% and offer higher capacity versus steel — 30 gal (113L) with pressure rating of 6000 psi (414 bar) compared to 15 gal (54L).

"Steel accumulators have been used for decades, but we're the first company to offer off-the-shelf composite accumulators into hydraulic hybrids to improve performance." Cantu sees a lot of opportunity, not only in rapidly developing applications for high-performance vehicles, but also in robotics and the customization Steelhead Composites offers. "We spin-form our own metal and complete composite winding in-house, so we can create custom sizes." For example, the MicroForce family of diaphragm accumulators are composite Type 3s that measure 125-158 mm in diameter, capable of 3,000+ psi (207 bar) and available in 0.5 and 2.0L internal volumes, weighing 0.5 and 1.78 kg, respectively. "As accumulators move into this world of smaller hydraulic devices, our ability to develop lightweight, tailored solutions are a real enabler for our customers."

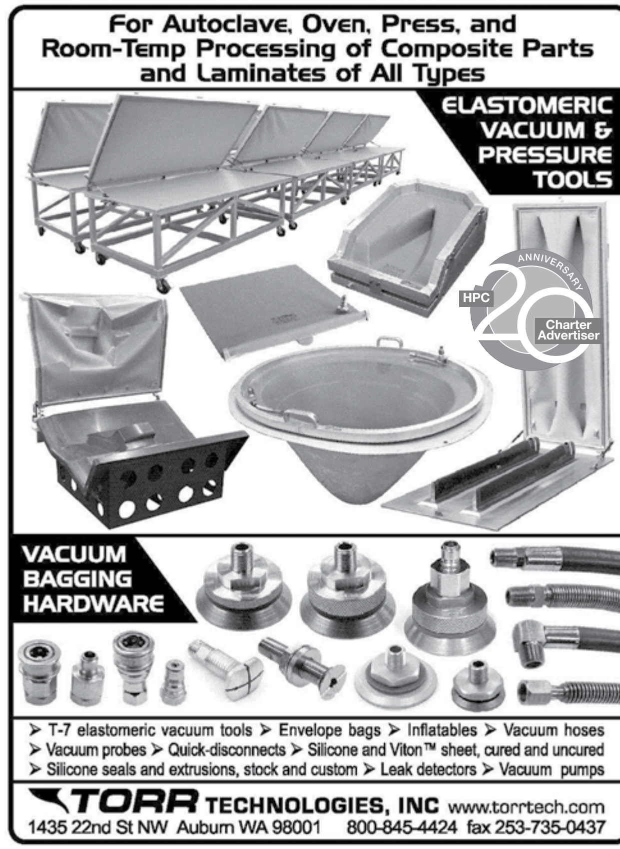
Read more online in the *CW Blog* | short.compositesworld.com/OilHybrid

Assembly Guidance becomes Aligned Vision

Assembly Guidance Systems Inc. (Chelmsford, MA, US) is changing its name to Aligned Vision, in the wake of the company's recent period of innovation and in the light of what it calls its expanded vision for composites fabrication management.

"Throughout the nearly 30 years since we launched the first industrial 3D laser projection system, our responsive efforts have brought about transformative solutions for composite fabrication," explains Scott Blake, the company's founder and president, "'Aligned Vision' more closely expresses this expanded mission."

Products emblematic of Aligned Vision's strategy includes the company's recently introduced complete fabrication management system for composites. This engineered solution incorporates the company's flagship LASERGUIDE laser projection system; its LASERVISION system that integrates a machine vision component and automates inspection; and its BUILDGUIDE process control system that replaces paper work instructions with comprehensive, step-by-step electronic work instructions, which may be controlled by the operator at the tool. Fabrication management also generates a "digital twin" of the as-built component, affording the fabricator, OEM and end-user full, lifetime traceability.



ACMA Executive Forum: Composites in the big, BIG picture

The American Composites Manufacturers Assn.'s (ACMA, Arlington, VA, US) Composites Executive Forum, designed to give composites executives a high-level view of the manufacturing and economic landscape, delivered as promised, Jan. 11-12, in Washington, DC. Forum speakers represented the American Chemistry Council, a bipartisan consultancy to the US House of Representatives and a variety of other interests. Many speculated about what President Donald Trump and the new US Congress might have in store for the United States.

Speaking most directly and specifically to that point was Lamar Smith, a Republican Congressman from Texas' 21st District, who said Trump and Congress will assess and roll back many regulations, particularly those deemed overly burdensome, unnecessary or unsupported by sound science. Further, he said Congress likely will pass a bill requiring that future regulations include the data that support their creation. Smith admitted, "We all want clean air and clean water, but regulations should be justified and beneficial, not unnecessarily burdensome." Congress, said Smith, is also working on making the US tax code simpler and more business-friendly. He said to expect the number of tax brackets to be reduced from seven to three, and to see incentives that encourage companies to stay in the US. Smith predicted that replacing the Affordable Care Act (Obamacare) will take about a year, and that the new healthcare system will focus on expanded use of private insurers and interstate competition, which, he asserted, will expand consumers' choices and reduce their cost. He also said the ACA's stipulation that a person cannot be denied coverage due to pre-existing condition will remain in place.

Cal Dooley, president and CEO of the American Chemistry Council (ACC), made many friends in the audience when he said, "We think there is going to be an infrastructure build in the new administration, and if there is, we want an open materials competition." That is, ACC wants non-legacy materials, including composites, to be given a chance to compete with legacy materials, such as concrete and wood.

"This is a white hat issue for us," he said. "This makes us look like heroes." Dooley also talked at length about the value of cheap natural gas in the US, noting that 85% of chemicals in the US are made with natural gas-based feedstocks, giving their manufacturers a substantial competitive advantage in the world market, he said. He, too, spoke — at length — about the need for regulations based on sound science, not fear. But Dooley expressed concern about Trump's rhetoric regarding trade restrictions or increased tariffs. "As a chemical industry," he made clear, "we want more trade, not less."

Lauren Bazel, VP of the Alpine Group, a bipartisan consultancy, emphasized that the value of composites is relatively unknown to most lawmakers, and that it's incumbent upon

Walton Process Technologies, Inc.
Mansfield TX 682-518-9002
Autoclaves
Bond Presses
Ovens
Batch Process Controls
Service/Repair
Retrofit/Relocate
Parts
WPT

Best Customer Service in The Industry
www.autoclaves.com

all composites industry players to engage with their senators and representatives to help them better appreciate it. She suggested inviting lawmakers to visit manufacturing plants, to see, touch and feel composite materials and understand their value.

Economist Robert Fry (Robert Fry Economics LLC, Hockessin, DE, US) looked at broader economic indicators for hints about the future, but did speak briefly to the roles of Trump and Congress. Although he generally favors regulatory, tax and energy-policy reform, he is opposed to backing out of trade deals, increased tariffs, deportations, and vilification of China and Mexico. Commenting on the latter, he noted that the best way to stem illegal immigration from Mexico is to help the Mexico's economy get better, not worse. Regarding global oil supply and demand, Fry asserted that the world might reach peak demand before it reaches peak supply.

Viewing the US amid the global market, Herb Meyer, a former intelligence analyst in the Reagan Administration, viewed the near term from the highest level. He billed his presentation as an "objective, agnostic" evaluation of the events and trends now shaping economic, demographic, religious and political systems.

Meyer emphasized, first, what he called the "good, under-reported news," including that the world is getting richer, and that 50-100 million people escape poverty each year. The global middle class is showing exceptional growth as well, providing unprecedented opportunities for manufacturers.

The biggest — again, under-reported — long-term challenge the world faces, he said, is population growth, or the lack thereof. Many developed countries are experiencing subreplacement fertility, which means newer generations are smaller than the generations they replace. Sub-replacement fertility is a birthrate below 2.1 children born per woman, and developed countries exhibit the slowest rate of population growth. According to the Central Intelligence Agency's *World Factbook*, the fertility rate in the European Union is 1.6; in Japan it's 1.4; in the US it's 1.9. Even China, thanks to its "one child" policy, now has a reported fertility rate of 1.6. The problem is that the larger older generation puts economic pressure on the smaller younger generation by way of demand for socialized services, such as healthcare and retirement programs. Funding these programs, Meyer said, strains the active workforce and stunts economic growth. Fertility rates, by the way, are highest in developing countries.

The good news? This global middle class will drive massive economic growth, and will need food, infrastructure, education, healthcare and entertainment — all categories, says Meyer, in which the US economy still excels.

CW MONTH IN REVIEW

Notes about newsworthy events recently covered on the *CW* Web site. For more information about an item, key its link into your browser. Up-to-the-minute news | **www.compositesworld.com/news/list**

McLaren Automotive to establish new Composites Technology Centre
The Centre will be responsible for the R&D of future Monocell and Monocage carbon fiber chassis structures as well as the manufacturing of the finished parts.
02/13/17 | short.compositesworld.com/McLarenCTC

CTC Global, General Cable expand ACCC conductor partnership
The agreement enables General Cable to assume a more comprehensive role in sales and distribution of CTC's composite-cored electric power transmission cable.
02/13/17 | short.compositesworld.com/CTC-GC

Roccor leverages SwiftComp software for composites simulation
AnalySwift recently licensed the SwiftComp technology through the Purdue Research Foundation Office of Technology Commercialization.
02/13/17 | short.compositesworld.com/SwiftComp

Lockheed Martin, Pentagon reach deal for "lowest-priced" F-35s
The contract is for 90 of the stealth fighter aircraft and represents more than a 60% price reduction for the F-35A variant since the first LRIP-1 contract.
02/13/17 | short.compositesworld.com/F-35newlow

SCIGRIP acquires Glue Boss
Glue Boss manufactures StoneBond and other high-performance surfacing adhesives.
02/13/17 | short.compositesworld.com/SciGripGB

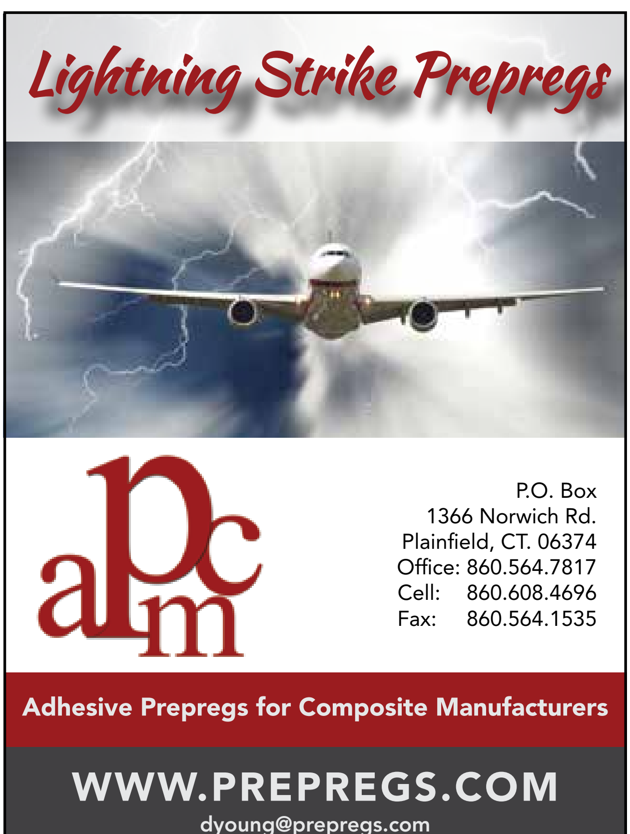
UTC Aerospace Systems licenses carbon nanotube-based de-icing technology
This technology was co-developed by Metis Design Corp. and the Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology.
02/13/17 | short.compositesworld.com/UTC-Deice

Composites extensively used in US Air Force communications tower
The 118-ft structure, which was completely constructed of composites, was installed by the Air Force at Hanscom AFB in the US state of Massachusetts.
02/06/17 | short.compositesworld.com/USAFtower

Composites-intensive *Hyperloop* pod takes first place in SpaceX competition
TenCate provided Delft University of Technology's team with the epoxy-based carbon fiber composite materials used to mold the winning pod's monocoque.
02/06/17 | short.compositesworld.com/Hyperloop2

CT Engineering Group to provide design support for A350 XWB
Since 2009, The CT Engineering Group has spent more than 600,000 engineering hours working on this project.
02/06/17 | short.compositesworld.com/CT-A350

Composites One buys BMB Solutions Composites
With this acquisition, Composites One expands its Canadian presence.
02/06/17 | short.compositesworld.com/CompOneCAN



BIZ BRIEFS

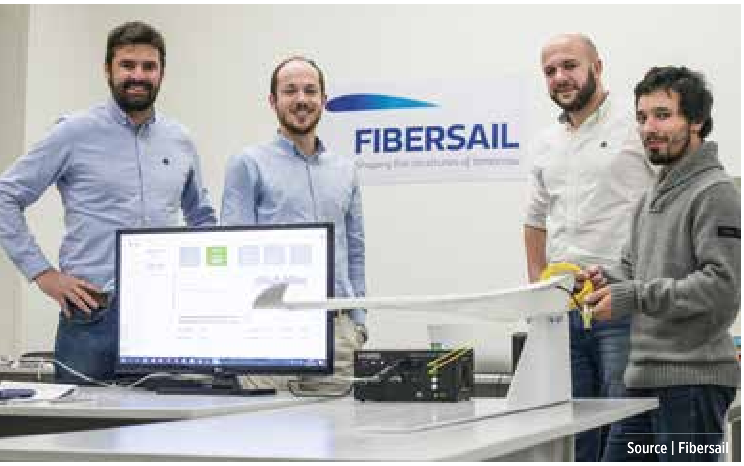
INEOS Styrolution (Frankfurt, Germany), founded as a 50/50 joint venture of BASF SE (Ludwigshafen, Germany) and INEOS, is bringing to market an innovative thermoplastic organic sheet for the manufacture of continuous fiber-reinforced composite components. The company claims that StyLight is the first and only thermoplastic composite material created from a styrene foam styrene-acrylonitrile (SAN) matrix with various glass or carbon fiber reinforcing textiles. The processing and molding is carried out in a similar way to other organic sheets on the market, but Styrolution says there are distinct advantages to this material: the SAN matrix has very low shrinkage and its gloss contributes to off-tool part surface quality that requires minimal post-processing. In support of this product launch, INEOS Styrolution is partnering with **CIKONI** (Stuttgart, Germany, a development partner for customers in the automotive, aviation, and consumer goods industry known for preforming) and **ESI Group** (Chartres-de-Bretagne, France) to ensure the availability of the necessary methods and tools for the virtual design of components for customers.

Turkey-based **Şişecam** will invest about US$100 million to build a new glass fiber plant in Balikesir, Turkey. It will have an annual capacity of 70,000 MT and is expected to become operational in the second half of 2018. Şişecam , originally Cam Elyaf Sanayii A.Ş., remains the sole manufacturer of glass fiber in Turkey, based in Gebze, Kocaeli, near Istanbul, and supplies customers in 30 countries worldwide. Balikesir, in northwestern Turkey, is very close to the Aegean region industrial cluster where 80% of wind energy manufacturers in Turkey are now located. The new plant will produce the company's current range of E-glass fiber reinforcement products.

The Balikesir plant is primarily aimed at serving customers in Europe looking for a reliable supply chain and a more local source of high-quality glass fiber products. Key markets for Şişecam glass fiber include wind energy, automotive, land transportation, marine, industrial, building and construction. To meet the specification requirements of key industry sectors, Şişecam has acquired various DNV-GL, Lloyds Register and FDA compliance certifications.

ENERGY

Structural health monitoring startup offers user-friendly system



Source | Fibersail

A company with a big vision for tracking the health of composite structures, Fibersail (Rotterdam, The Netherlands and Leça de Palmeira, Portugal), says it has developed a system to monitor and analyze the behavior of wind turbine blades in terms of shape, in real time. The reportedly user-friendly system provides data to help operators avoid blade failures and reduce overall wind farm maintenance costs.

CEO and company co-founder Pedro Pinto spoke to *CW* recently to describe the Fibersail system and its benefits. Several fiber-optic cables, fitted with multiple Fiber Bragg Grating (FBG) sensors, are applied to a flat composite batten. The sensors are "related" to each other by the company's proprietary algorithms and software, which allow monitoring of both flapwise and edgewise movements for documentation of three-dimensional structural deformation. The batten or measurement tool is not intended to be embedded within a composite laminate, but rather to be adhered on the interior or exterior surface of the structure to be measured (e.g., wind turbine blade), preferably in a pre-fabricated slot, but in theory anywhere appropriate for that structure, says Pinto: "Imagine a ruler that you use to measure. We consider our sensor like a digital ruler, which the client can simply attach and start measuring. It could be placed inside the wind blade for monitoring in the real environment, or on the outer surface in testing facilities."

Fibersail doesn't require specialist operators for application purposes, but rather allows engineers access to a machine learning-based user interface in a tablet-readable system, says Pinto: "We ship a ready-to-use system that requires no special interpretation." He points out that if an embedded FBG system (within a laminate) has a problem or stops working, that structure can no longer be monitored without disassembly access.

The company's goal is a simpler, efficient method of critical structures monitoring, one that eliminates time-consuming manual visual inspections of turbine blades by climbers. Reducing these inspections can significantly reduce wind farm costs. Plus, the real-time monitoring can alert operators to impending catastrophic blade failures, and allow targeted maintenance only where needed. Pinto says a test will be undertaken this spring in Europe in collaboration with a well-known blade producer to verify the Fibersail system in an installed wind farm. "We offer a technology that can reduce costs compared to older monitoring strategies, and yet give precise and accurate information for operators," concludes Pinto.

Visit the company's Web site for more information or contact the group online | **www.fibersail.com**

See *CW*'s story on structural health monitoring in aerospace online | **short.compositesworld.com/SHMupdate**

DELIVERING THE FUTURE
OF COMPOSITE SOLUTIONS

Gurit

With sales offices and engineering support in the US, Europe, and Asia / Pacific, as well as production sites in North America, Europe and Asia, Gurit is ideally positioned to serve its local customers with truly global resources.

Gurit ensures the success of any project through its extensive experience across a variety of markets, combined with unrivalled engineering support and design services, the industry's best kit designs and production, and customer-focused local sales support.

For more information on Gurit's full composite offering and expertise:

www.gurit.com

ENERGY

Composites on the upswing in oil and gas?

Subsea oil and gas exploration and delivery has long been pointed to as a potentially lucrative end-market for composites in pipe and related structures. Indeed, given the subsea oil and gas industry's need for durable, tough, lightweight materials that do not easily corrode, composites seem a perfect match. However, as with many industries, legacy materials are not so easily forgotten, so composites migration into this market has been slow.


Source | Magma Global

There are recent signs, however, of possible change. Two announcements in late January signaled that large players in the chemical industry are seeing real opportunity, and investing. The announcements involved two of the biggest providers of composite pipe to the oil and gas industry, Magma Global Ltd. (Portsmouth, UK) and Airborne Oil & Gas (IJmuiden, The Netherlands).

First, thermoplastic materials specialist Victrex plc (West Conshohocken, PA, US) announced on Jan. 25 that it is taking a minority interest in Magma Global. Following the joint development of Magma carbon composite m-pipe using VICTREX PEEK, Victrex made the minority interest investment in Magma to further facilitate the adoption of its m-pipe for subsea applications. The m-pipe technology is expected to reduce exploration and production costs and risks for demanding subsea applications.

"The oil and gas market remains challenging, but the application of m-pipe in areas where it can deliver cost savings for operators, through simpler design, easier deployment and in whole-life costs, means it should be the technology of choice for demanding subsea applications," says Martin Jones, CEO at Magma.

Then, on Jan. 27, Sumitomo Corp. Europe (London, UK) announced a global commercial cooperation agreement for the sale and distribution of thermoplastic composite pipe (TCP) manufactured by Airborne Oil & Gas

"The intrinsic properties of the TCP, such as no corrosion, low weight and end-fittings that are installed quickly offshore, provide our clients with unmatched opportunities to reduce cost, both CAPEX and OPEX," says Martin van Onna, CCO with Airborne Oil & Gas. "With our DNV qualifications and fast-growing track record in the global SURF market, the TCP is widely recognized for its potential as alternative to steel and flexible pipe. This makes 2017 the ideal year to expand in to the global market."

CompositesWorld

WEBINARS

It's free. It's remote.
It's informative.
It's convenient.

SIGN UP TODAY!

Troubleshooting Common Gel Coat Application Issues

DATE AND TIME:
March 14, 2017
2:00 PM EDT

PRESENTED BY:

JOHN SAWAYDA
Polynt,
Technical Assistance

STEVE DEARING
Polynt,
Technical Assistance

polyntcompositesus.com

EVENT DESCRIPTION:

This webinar is for anyone tasked with solving production issues related to gel coat application. Polynt's industry-leading technical representatives will discuss causes of common problems, methods for diagnosis and resolution, and review best practices to prevent recurrence.

This session will be based on Polynt Composites Application Center's (PCAC) Gel Coat Application Course, which is part of Polynt's industry-leading composites training program. Presenters Steve Dearing, known in the industry as "Dr. Gel Coat," and John Sawayda have a combined 80 plus years of experience in the composites industry – including gel coat development, gel coat production, and numerous gel coat applications.

PARTICIPANTS WILL LEARN:

- Root causes of common gel coat problems
- Methods for diagnosing common gel coat problems
- Methods for resolving common gel coat problems
- Best practices to avoid problem recurrence

REGISTER TODAY FOR WEBINAR AT:
Reg Link: http://short.compositesworld.com/Polynt314

Tackling Automotive Industry Challenges with Specialized Software Solutions

DATE AND TIME:
April 12, 2017
2:00 PM EDT

PRESENTED BY:

GEORG KAESMEIER
Managing Parnter,
Forward Engineering

ED BERNARDON
Vice President,
Strategic Automotive Initiatives, Siemens PLM Software

siemens.com/plm

EVENT DESCRIPTION:

In this presentation, we will discuss automotive industry changes and how the latest trends will affect the way cars are designed as well as some of the challenges that design engineers face when using mixed materials.

Attendees will gain an understanding of how specialized software solutions can address the unique challenges faced by the automotive industry in incorporating mixed materials and new technologies.

PARTICIPANTS WILL LEARN:

- the major changes we'll see in the future in regards to how cars are designed
- the evolution of lightweighting and why it has become so important
- the benefit of having a mixed material strategy
- benefits of using engineering software when designing with composites/mixed materials

REGISTER TODAY FOR WEBINAR AT:
Reg Link: http://short.compositesworld.com/Siemens412

AEROSPACE

Victrex, Tri-Mack JV targets PAEK composites to aerospace

Victrex Plc (Thornton-Cleveleys, UK) and Tri-Mack Plastics Mfg. Corp. (Bristol, RI, US) have formed a joint venture, called TxV Aero Composites, to accelerate commercial adoption of polyketone (PAEK) composites in the aerospace industry. The multi-million-dollar investment includes a center of excellence in the US, scheduled for completion this year. It will offer a range of PAEK composites, from custom laminates to pre-formed inserts for hybrid molding processes, as well as finished parts and complete over-molded hybrid parts and assemblies that can deliver up to 60% weight savings compared to metallic solutions, and offer continuous manufacturing processes and cycle times measured in minutes vs. hours.

"We can offer new forms and components, alongside supplying materials, and build a new supply chain to address the unmet needs of the aerospace industry." says David Hummel, CEO of Victrex.

"With an estimated 35,000 new aircraft to be launched in the next 20 years ... [t]he efficient processing and performance advantages of PAEK thermoplastic composites ... will position TxV Aero Composites to meet the industry's cost and weight challenges," says Tri-Mack president Will Kain.

Take the Lead.

From weaving preparation to shed formation to individually configurable weaving system solutions, Stäubli offers innovative machines and systems that produce high quality technical textiles for a wide range of applications. Pick up Stäubli's know-how and rise to the top of the textile charts.

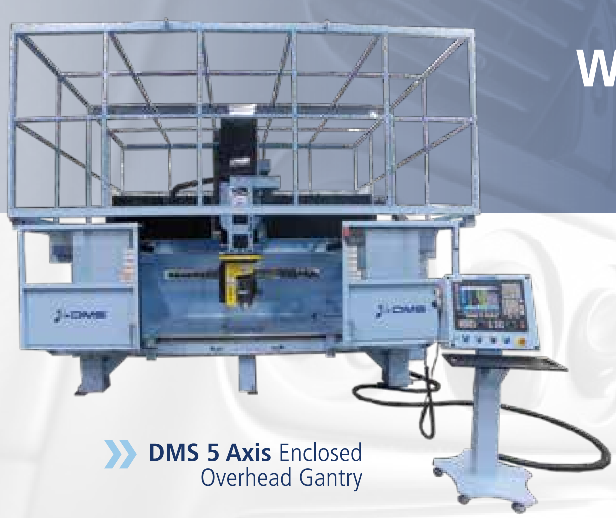
www.staubli.us/textile

FAST MOVING TECHNOLOGY STÄUBLI

Visit us at JEC
Pavilion A6, Stand A64

DMS DIVERSIFIED MACHINE SYSTEMS

World Class CNC Machinery
3 Axis & 5 Axis



DMS 5 Axis Enclosed Overhead Gantry

30+ years of innovation, custom engineering and industry experience as an Original Equipment Manufacturer (OEM), Diversified Machine Systems is trusted by industry leaders to produce a superior machine and deliver the ROI.

Fully enclosed 3 Axis & 5 Axis CNC solutions with proven results in the composite industry. Our experienced engineers will design you a custom CNC solution to meet your company's production needs.

3 Axis & 5 Axis CNC Routers | 866.255.AXIS | DMSCNCRouters.com |

CONSTRUCTION

Composites meet architectural needs in UK

ACELL Industries Ltd. (Dublin, Ireland), a provider of innovative building material systems and construction methodology (see endnote), is building marketshare for its patented, customizable sheet molding compound (SMC)-based insulated building products in the United Kingdom, where it is partnered with Phil Coppell Group Ltd. (PCL, Radcliffe, Manchester, UK). A well-known contractor and supplier of roofing, windows and doors and building extensions (additions), PCL has invested in the ACELL process, with a manufacturing line in its factory: "We can make bespoke modular roofing products for each customer that match that home's appearance, with excellent insulation value, that can be installed in a fraction of the time of traditional materials. We see major, major benefits with this technology," says Jim Flanagan, PCL's group managing director.

ACELL has found success in Europe, particularly in the UK, where there exist more than 7 million poorly insulated and some uninsulated homes and buildings built before 1919. A 2015 report from the UK's Association for the Conservation of Energy (London, UK) reveals that the UK has very high building-space heating costs, and, on the European Union's "A to G" rating system of energy efficiency (where A is the least energy use), the UK rates


Source | Acell

"D" or below. This poor rating resulted in spite of the fact that UK gas and electricity prices typically are lower than those in many of the 15 other European countries surveyed. Energy efficiency renovation, however, must be done in accordance with UK planning and building regulations, which curtail any changes to a building's original

appearance if it is located within an area of "natural beauty" or a "conservation area," says Flanagan.

Flanagan describes several recent projects for replacement of conservatory roofs, using molded ACELL roofing panels. The SMC/foam molded panels are made in sections ranging from 0.8m^2 to 1.8m^2 in size, that replicate exactly the desired material, such as Welsh slate, clay or Roman terra cotta, for example. PCL then adds a carrier structure, usually aluminum-based, to support the panel, and fasteners to attach the panel to the roof structure. Panel insulation value can be increased if needed by adding more foam.

Acell's patented molding technology combines SMC skins and a core of frangible yet fire-resistant phenolic foam, which was developed by the company nearly 30 years ago. The foam offers insulation value; flame, smoke and toxicity (FST) protection; and acoustic damping properties. Notably, the skins can be made to replicate virtually any architectural surface texture, including brick, slate or very contemporary designs, says Acell's executive director Michael Frieh. Color and surface treatments are duplicated via in-mold-applied coatings, natural sand and/or printed fabrics.

Reports are that PCL customers with installed ACELL conservatory roofs give positive reviews on the overall appearance, plus the installers themselves are very happy with the huge savings in time and labor during installation. Says Flanagan, "ACELL molded roof panels — made to look like Welsh slate — for example, speed up onsite installation and efficiency tremendously, and can be completed in all weathers." He notes that ACELL panels can be used in low roof-pitch situations, where traditional slates or clay tiles can't be used, which gives PCL an advantage.

At *CW* presstime, PCL planned to introduce an insulated wall panel system, or SIP (structural insulated panel), for factory-built modular homes, which Flanagan calls "a massive growth market." Residential housing in the UK is in short supply, and Flanagan estimates that modular homes built with the SIP system, which PCL can build with the ACELL panel, will grow by 300,000 units in 2017 alone. PCL and ACELL are working closely together to increase manufacturing capacity for the project.

Concludes Flanagan, "We're taking a commercial approach to this composite technology for building products. We believe it can totally revolutionize building and construction, and we don't say that lightly. This is an extremely exciting time for us." ACELL also plans to move forward with expansion into new, non-European markets. Learn more online about how the products are made | **short.compositesworld.com/KeUV5dzY**

Composites in Class A body panels: Evolution continues

Low-density SMCs lead the way as fiber-reinforced polymers make headway in auto components that must please the eye.

By Ginger Gardiner / Senior Editor

» Class A is a qualifier for the surface finish of automotive body parts. For composites, it means that flatness, smoothness and light reflection is equivalent to that attainable with steel, and indicates the part's ability to compete with metal in paintability or as-molded cosmetics. How a part achieves Class A finish impacts body-in-white (BIW) assembly and coating processes — for example, can the parts be painted in-line or must they be painted offline and attached beyond the body shop? These differences, quantified in seconds, scrap rates and dollars, ultimately define a model's bottom line.

Composites have been used in Class A automotive parts since the 1940s, but their use has seen significant swells and setbacks (see Learn More, on p. 34). Current market projections agree that car models in the foreseeable future will use multiple materials — including high-strength steel, aluminum and fiber-reinforced composites — to comply with regulations for reduced fuel consumption and emissions.

Class A remains a requirement for car closures (e.g., fenders, hood, trunklid/decklid, roof, doors, quarter panels), and also a challenge, as OEMs seek to use composites to navigate not only lightweighting, but also global supply, modularization and demand for an increasingly multifunctional vehicle envelope. A big question is, which composite materials and process options will meet these requirements?

Aluminum as target

According to a June 2016 presentation by IHS Markit (London, UK) automotive forecaster Michael Robinet, closure manufacture will shift to aluminum from steel by 2022-2023, and then to CFRP and other composites before 2030. This change in materials bodes well for suppliers and fabricators of fiber-reinforced sheet molding compound (SMC). "Our competition in SMC used to be other molders," says Mike Siwajek, director of R&D at Continental Structural Plastics (Auburn Hills, MI, US), a manufacturer of parts using SMC and other composite materials. "Now we compete head-to-head with aluminum on weight, cost and surface finish."

Notably, CSP has received many awards for its low-density TCA Ultra Lite SMC with a specific gravity (SG) of 1.2, in production on the General Motors (Detroit, MI, US) *C7 Corvette*. Tooling cost for SMC is much lower than for steel or aluminum stamping, offering as much as a 50% reduction. "This gives CSP's molded SMC parts a cost advantage on Class A parts up to 150,000 units per year," he explains. "Above that volume, the cost *advantage* goes away, but we are still *on par* with metal."

Cost parity at high volume is a powerful asset, says Siwajek. "OEMs are trying to take platforms global vs. having a different model for each continent." Economies of scale are achieved by making the same parts worldwide, and SMC augments this advantage. "For example, three to five dies are required for a stamped steel part," he explains, "but with SMC, only one tool is required, greatly reducing the investment needed for global supply."

State-of-the-art SMC panels

The 2016 Jeep *Wrangler* roof features two Class A surfaces on a single SMC part molded by Continental Structural Plastics (at a rate of 900 parts/day). The company has also reworked a traditional SMC decklid (inset), combining a carbon fiber RTM inner and TCA Ultra Lite SMC outer to cut weight 13% vs. aluminum.

Source | Continental Structural Plastics

Another aspect of this trend is to build fewer, globalized platforms, but increase the number of model *variants*, each specialized to meet different customer demands per region and age group. "For example, in the late '90s/early 2000s, *Mustang* had five to six different hoods for models, offering styling and performance tweaks, like the *Mach 1*, the *Shelby*, etc.," Siwajek explains. "SMC helps to do this very cost-efficiently."

"We're also starting to get into different geometries where metals struggle," Siwajek adds, "for example, in liftgates and doors, where we can produce fully assembled components to reduce complexity and weight." One of CSP's initiatives is benchmarking current designs and products, answering key questions: "Where can we save weight and provide value? How can we provide relief where OEMs are having issues?" He offers, for example, a part comprising a magnesium inner and an aluminum outer. "There are distinct disadvantages to these materials," Siwajek argues. "They aren't as dimensionally stable, which causes issues during painting and assembly. They also pose a significant risk for galvanic corrosion." He says CSP is working with multiple OEMs to move away from metal. "Many are afraid of putting SMC through the E-coat process at temperatures above 210°C, thinking that 'plastics' won't handle it. But our TCA parts do that, no problem."

FIG. 1 Fully automated SMC production

Aliancys' new SMC line (top) at its Zwolle, Netherlands R&D facility is shown here cutting carbon fiber bundles onto a foil (center), which are then covered by resin and compressed by belt into the final sheet product (bottom). Source | Aliancys

Competing composites

SMC, however, is not the only composite under consideration as carmakers pursue multi-material designs for lightweighting. Reinforced thermoplastics and carbon fiber composites also have evolved, though not everyone is convinced of their performance in Class A applications. Michael Polotzki, managing director for SMC compounder Menzolit (Turate, Italy), sees two reasons why thermoplastics are not as competitive for Class A body surfaces. "First, the thermal elongation is two to three times higher than SMC," he explains, "which makes it very difficult to meet tolerance requirements, especially on larger parts. Second, the stiffness of the part is not high enough so that you have to add reinforcing structure. This adds cost, weight and production complexity." Polotzki also asserts it is difficult to incorporate ribs and struts into thermoplastic parts without seeing these print through to the visible surface. »

SIDE STORY

SMC 4.0

Problems with painted SMC parts began in the late 1990s, perhaps due to high growth and adoption on high-volume models. "When I started in 1999, Class A applications of SMC had serious issues with edge pops or paint pops," recalls Mike Siwajek, director of R&D at Continental Structural Plastics (Auburn Hills, MI, US). "We were seeing 250-350 concerns per 1,000 parts, which was unacceptable," he recalls.

ThyssenKrupp Budd (now CSP) began to catalog the defective parts and do root-cause analyses, tracing 90% of the defects to microcracks in the cured part surface. Siwajek explains, "We were molding the SMC parts and shipping them to the assembly line, where the guys would treat them like steel parts, dropping them, using mallets as they attached them to the BIW. The paint film would cover the microcracked area, trapping air, which would then expand during cycling in the paint oven, causing 'fish eyes' all along the edges of the part."

Siwajek's team knew it couldn't control how the auto plants handled the parts, so it worked with resin supplier AOC (Collierville, TN, US) to increase the toughness of the SMC's polyester matrix. Both ThyssenKrupp Budd and AOC hold patents on the resulting tough Class A (TCA) technology for SMC. "By the end of 2002, Ford had stopped counting SMC paint defects because we had basically eliminated the issue," says Siwajek. "However, by that time we had already missed the new model cycle."

"When CSP bought us in 2006," he continues, "though we had always been on the *Corvette*, we were just getting back onto other models when the industry moved to lightweighting." At that time, the TCA product had a specific gravity (SG) of 1.9, but the company had already introduced the mid-density 1.6 SG product which went on the *C6 Corvette*. "So we jumped to the TCA UltraLite at 1.2 SG," says Siwajek, "which is on the *C7 Corvette*."

Along the way, CSP also was able to eliminate other issues in compounds and molded parts, not only through best practices but also through methods of part design. Siwajek explains, "For example, Ford gives us the design envelope, but we have a unique way we treat edges, radius requirements, etc. So 90% of any manufacturing issues were eliminated through TCA toughness development and the last 10% through design and process improvements."

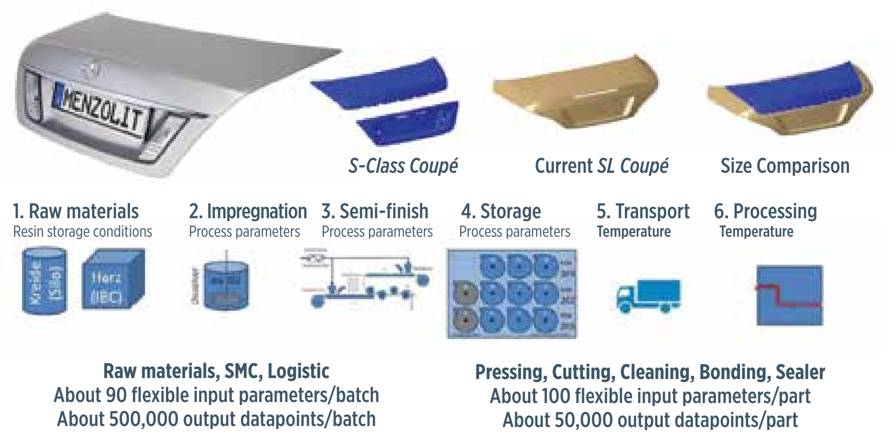
SMC compounder Menzolit (Turate, Italy) also faced unacceptable levels of defects and scrap rates by the early 2000s, and began working with resin supplier Aliancys (Schaffhausen, Switzerland) and automaker Daimler AG (Stuttgart, Germany) to collect raw materials and parts manufacturing data and correlate it to surface finish (mainly waviness). This effort was extended in 2008, to establish an automated system that would collect and analyze comprehensive data as a standard mode of operation. It was implemented specifically for the molded SMC decklid on the Mercedes *S-Class Coupe* model upgrade. Most recently, it was applied to the 2012 Mercedes *SL Roadster*.

"The idea for this second effort was to fully open the books of all three partners," explains Menzolit managing director Michael Polotzki, "not only looking at production data, but also each partner's storage and transportation data. Our goal was to put this data together and try to find correlations in order to optimize production and reduce the scrap rate throughout the process chain." For the 2012 Mercedes *SL*, the focus was on Daimler's in-house molding of the decklid to resolve an unacceptably high scrap rate, close to 35%." This part had integrated a previously two-part design, with an upper horizontal and separate license plate panel, into a single, larger part with longer flow paths from the injection point.

The initiative quickly established relationships between process variables and finished-part metrics. "The SMC batch had a direct influence," Polotzki recalls. "We could see an increase in scrap rate at Daimler when there were changes in the raw material batch. So we began an initiative to reduce deviations from batch to batch."

In another example, Daimler changed from one type of tool element to another and saw a significant improvement in molding results. Aliancys also saw correlations to its material production. "Now we have reduced the scrap rate to below 5%," says Polotzki, who notes that a single, common digital platform was used to share and analyze the data on a weekly basis. "We had meetings to present and discuss the data," he says, "but as we achieved results, we reduced these to every two weeks, then every month and now we meet quarterly."

Will this become standard procedure for all of Menzolit's programs? "We are working with other automotive customers to go this way," says Polotzki, "but for various reasons, so far there is not the same degree of openness as with Daimler." He says the benefits go beyond scrap reduction, including identifying appropriate tolerances for process parameters and an insight into other process improvement options, which in turn increases process flexibility and reduces cost.



Main steps of the SMC process chain from raw materials to molded part

Process data management

SMC compounder Menzolit partnered with Aliancys and automaker Daimler to establish an automated system to collect and analyze comprehensive process chain data for the 2012 Mercedes *SL* molded SMC decklid. Larger and more complex than previous versions, it reduced the scrap rate from 35% to less than 5%.

Source (top left) | Menzolit / Source (top right) | Daimler / Source (bottom) | Aliancys

FIG. 2 Less weight and lower cost

Plastic Omnium's carbon fiber-reinforced tailgate prototype (left) offers a 10% weight reduction compared to an all-aluminum design, while its Higate hybrid tailgate (right), with molded in color for the Citroën C4 *Picasso* integrates a Class A LGF PP outer, an SMC inner, lights, antennae, motorization and crash protection at less weight than steel and at low cost. Source | Plastic Omnium

But thermoplastics might be developing new support with carbon fiber. Gary Lownsdale, president of Trans Tech Intl. (Loudon, TN, US) and a 50-year veteran of the automotive and composites industries, sees the trajectory of carbon composites in automotive moving toward thermoplastic resins for two main reasons: fast processing for <2-minute cycle times and the ease of injection molding compared to resin transfer molding (RTM). "Injection molding is now a very well-understood and well-controlled process," he explains. "It is easy to model the parts and simulate the process with readily available software. It is also a high-pressure process, which helps with complex shapes and consistent quality." What about high-pressure RTM (HP-RTM) using thermoset resins? "HP-RTM is reaching toward injection molding," says Lownsdale, "but there are still many unknowns."

Lownsdale rebuffs the issue of print-through in thermoplastics, noting that it remains a concern for SMC as well. "There are techniques to overcome this, like using a thin veil against the tool," he acknowledges. "Another solution is gap molding, where they bring the press down and then back it off just enough to allow a resin-rich surface before closing the press to finish molding." Lownsdale also sees some molding limitations. For example, he believes fenders are not as well-suited to SMC, "because they are much more complex in shape." He also points out that some SMC molders still struggle with paint defects.

CSP and Menzolit say they have overcome these problems, adopting Industry 4.0 data analysis to drive part defect and scrap rates close to zero (see Side Story, "SMC 4.0," on p. 30). Polotzki says the "paint pop" issue is well known with SMC (see Learn More). "We advise the molder to use in-mold coating (IMC) technology and avoid these problems." He says IMC closes the material surface, eliminating pinholes. "It costs a little bit more, but the result is much better. It enables electrical conductivity in the surface so that these parts can go through inline painting."

Siwajek says European OEMs have continued to have some issues with painted SMC, but notes they also have taken different approaches. Some OEMs have brought parts molding in-house, while others have used hybrid systems that feature a thermoplastic outer with an SMC inner. "The problem is such parts have to be painted outside of the factory, handled carefully as they are shipped into the assembly line and then attached *after* the E-coat process, which adds complexity, cost and risk." Siwajek notes that one of his company's highest volume jobs currently is the Jeep *Wrangler* roof (see the opening photo on p. 28) for Fiat Chrysler America (FCA, London, UK). "It is a unique application because it has a Class A surface on both the inside and outside of the part. We make up to 900 of these per day."

Carbon fiber SMC

Looking ahead, the demand for lightweighting will prompt serious efforts to incorporate carbon fiber reinforcement into SMC. "We are working on several projects looking at carbon fiber in SMC for serial applications," says Polotzki. "However, at the current price of carbon fiber, this will only be used in niche products, such as high-end and premium cars." What price would enable use of carbon fiber SMC in mass production vehicles? "Below €11/kg [US$5.3/lb]," Polotzki replies. "Then it makes more sense as a means to reduce density, wall thickness and, thus, weight."

Menzolit's partner in applications for automaker Daimler AG (Stuttgart, Germany), Aliancys (Schaffhausen, Switzerland), also has moved forward with carbon fiber, installing a new SMC line at its R&D facilities in Zwolle, The Netherlands, for trialing a full range of SMC products with customers. "We have made the development of carbon fiber-based solutions a key priority in our long-term strategy," says Aliancys CTO Paul Vercoulen.

Magna Exteriors (Concord, ON, Canada) was recognized by the Society of Plastics Engineers (SPE, Bethel, CT, US) this past »

October for the first compression-molded carbon composite hood on a production vehicle. The bonded, two-piece hood for the 2016 *Cadillac ATS-V* and *CTS-V* sedans uses fast-curing carbon fiber/epoxy prepreg. Six plies of 50K uni carbon fiber are used for the outer panel, and a fabric weave is used for the inner panel, both from Barrday Composite Solutions (Millbury, MA, US). The hood weighs 27% less than an aluminum version. Robotic preform and material loading processes reportedly help drop cycle time below 10 minutes, enabling volumes up to 30,000/year. The hoods are painted, with an option for exposed weave on the inner panel.

Magna's above announcement followed its launch of EpicBlendSMC EB CFS-Z, an SMC developed using Zoltek's (St. Louis, MO, US) Panex35 commercial carbon fiber, compounded at its Grabill, IN, US, plant and available for sale to other molders. Initial applications were structural. All Magna Exteriors composites operations were acquired by CSP in July 2014, making CSP the world's largest SMC fabricator.

"Our approach is to put carbon fiber where it makes sense," says CSP's Siwajek, "for example, using hybrids with glass fiber where the carbon is for reinforcing structures. Through design, you can get the best bang for your buck, and achieve unique, cost-effective solutions."

Polynt Composites Germany (Miehlen) has offered CF-SMC since spring 2016, targeted initially to structural applications but with Class A products in development. "Our Polynt-RECarbon products are reinforced with recycled carbon fiber mats," says product development manager Nicole Stoess. "We also offer Polynt-SMCarbon (3K-50K) SMC in both epoxy for autoclave processing, and epoxy and vinyl ester SMC for compression molding." She notes further that "several, well-known European automotive companies have expanded their use of CF-SMC significantly enough that Polynt has recently added a new 1.5m-wide SMC machine, fully dedicated to customized carbon fiber materials."

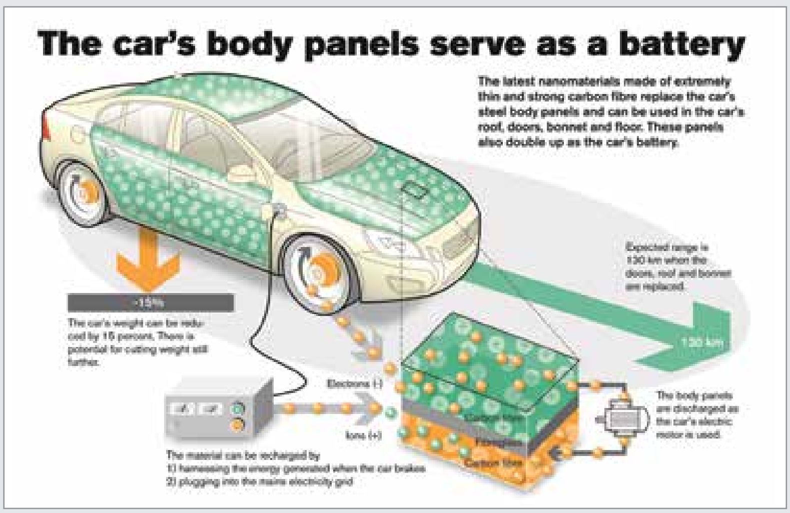
Covering all the composite bases

"What I see for 2020-2025 models is hybrid materials," says Lownsdale, who clarifies, "not just combining steel with aluminum and CFRP, but a combination of thermoplastics, thermosets and carbon fiber." He notes, as and example, a decklid using injection molded thermoplastic for the outer panel and RTM'd CFRP for the inner panel, adding, "This approach works in hoods and roofs also. Processes that never appeared to be similar, we can now combine."

CSP also has produced a Class A panel with RTM CFRP inner, but this one with a TCA Ultra Lite SMC outer, developed by its European R&D group. "They won a 2016 CAMX award for this multi-material decklid which uses recycled carbon fiber material," Siwajek relates. "They reworked a traditional SMC part to cut weight by 13% vs. aluminum." The parts were molded in less than 3 minutes using a fast-cure epoxy resin from Hexion (Columbus, OH, US). "These low-cycle-time resins put RTM on par with SMC," claims Siwajek, noting that Teijin Ltd.'s (Tokyo, Japan) recent purchase of CSP is

SIDE STORY

Composites in Class A body panels: Integrating energy storage



Multifunctional composite

Led by Imperial College and automaker Volvo, the STORAGE project demonstrated a structural supercapacitor roof and a trunk lid with supercapacitor laminates that cut weight 60% over existing components. The rechargeable panels comprise multiple layers of epoxy-impregnated carbon fiber insulated by fiberglass inserts. Source | Volvo Cars

Intended to develop composite body panels that could store and release energy like a battery, the European Union-funded project STORAGE (2010-2013), led by Imperial College (London, UK) and Volvo Cars (Gothenburg, Sweden), demonstrated a structural supercapacitor roof and a trunk lid with supercapacitor laminates that cut weight 60% compared to existing components. The rechargeable panels comprise multiple layers of carbon fiber/epoxy insulated by fiberglass inserts (see above). Parts were made using Solvay (Woodland Park, NJ, US) MTM47 out-of-autoclave prepreg.

A variety of material approaches were investigated for efficient energy transfer, including carbon aerogel reinforcement of carbon fibers and multifunctional matrices (e.g., 50/50 weight mixtures of epoxy resin and ionic Li salt solution). Volvo claims such panels could power its *S80* hybrid demonstrator vehicle's 12-volt electrical system. Project teammate Swerea SICOMP (Piteå, Sweden) has filed patent applications for carbon fiber batteries.

There also has been an increase in car models with photovoltaic solar panels in the roof. "The military has been developing battery panels and embedded solar panels for years," says Gary Lownsdale, president of Trans Tech Intl. (Loudon, TN, US). "Again, hybrid composite materials offer a lot of opportunity, for example adding carbon nanotubes and other nanomaterials. Embedding flexible electrical circuits in body panels is also an attractive development because you can get rid of the wiring harnesses and simplify the supply chain and assembly."

increasing his company's access to a range of new fibers and thermoplastics.

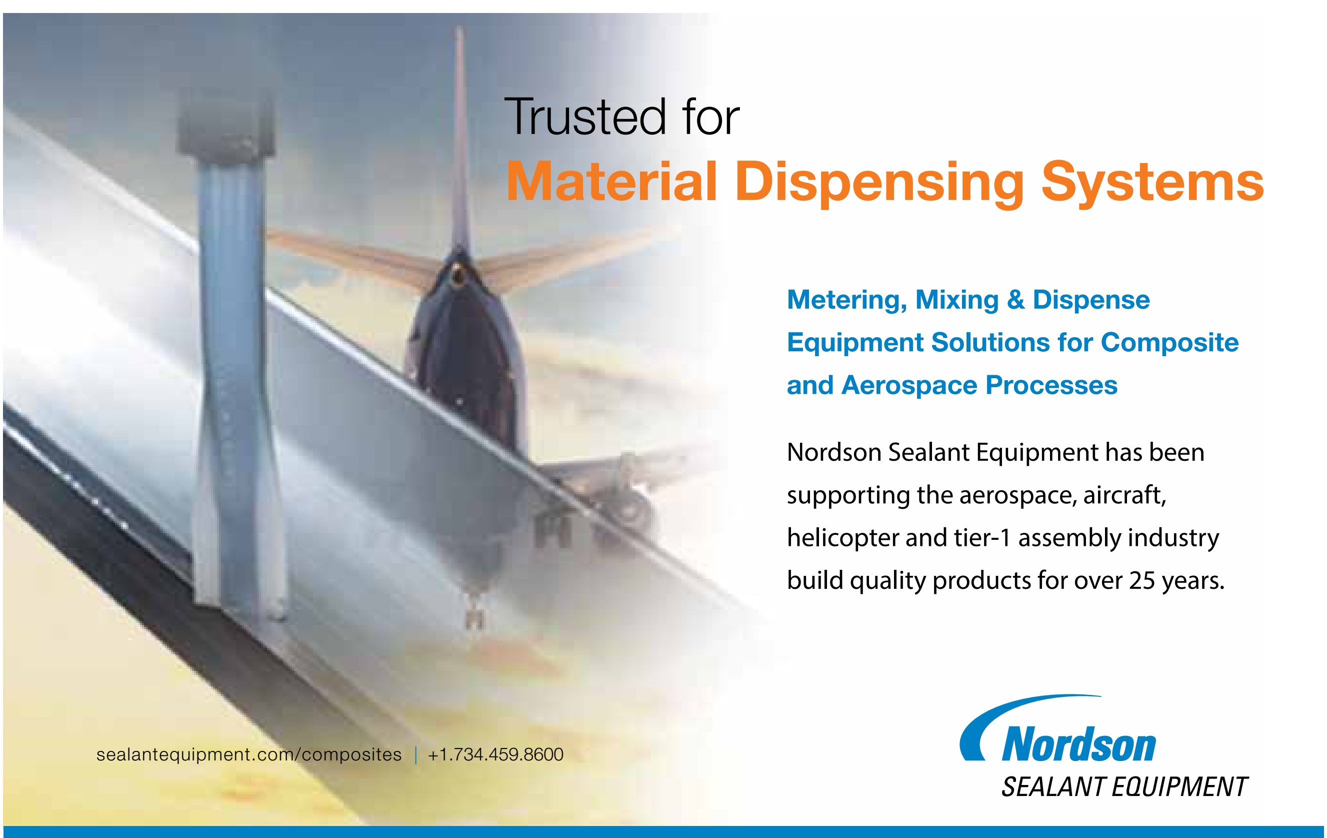
Indeed, fast-cure resins and the HP-RTM process were developed specifically to deliver low-cycle-time composite auto parts, making them more competitive with metals. Although originally developed with polyurethane and epoxy, HP-RTM using *thermoplastic* resins is now an option, as are hybrid processes that combine thermoforming and overmolding — injection molding thermoplastic on top of the molded composite substrate (see Learn More).

Another trend is a move by traditional neat plastics molders into structural composites. A case in point is Plastic Omnium (Île-de-France, France), the world leader in plastic auto exteriors. It turned out 27 million bumpers, 5 million front-end modules, 1.2 million tailgates, 1.5 million fenders and 1 million spoilers in 2015 — *and* made 3 million *composite structural* parts, touting abilities in thermoplastics *and* thermosets as well as development of carbon fiber and smart materials. Introduced in 2013, its hybrid thermoplastic/composite Higate tailgate integrates a Class A long glass fiber-reinforced polypropylene (LGF PP) outer with SMC inner. Used on Peugot, Range Rover, Jaguar and Citroën models, Higate also is the company's first *composite* tailgate in China for the Roewe *E50* electric vehicle.

FIG. 3 Smart composites: Integrated and interactive

Plastic Omnium is already investing in smart composite materials for more integrated functions and production of complex, interactive, fully assembled modules. Source | Plastic Omnium

This ability to mold parts across a spectrum of materials and processes is also being embraced by new entrants into automotive composites. In 2015, Tier 1 auto exhaust/emissions control specialist Katcon (Santa Catarina, Nuevo León, Mexico) launched Katcon Advanced Materials (KAM) at its headquarters near Monterrey. Offering composites design and manufacturing for lightweighting vehicles in a new »



9300m² facility, KAM's full range of processes includes thermoforming, injection molding and light RTM. It was reportedly the first North American company to install an HP-RTM machine (supplied by Engel, Schwertberg, Austria) fitted with polyurethane (PUR) injection technology (from PUR processing machinery specialist Hennecke, Sankt Augustin, Germany). In 2016, KAM licensed "crush core wet-pressing technology for Class A surface" from Magna Steyr (Graz, Austria). A modification of composite spray molding (CSM), the method combines sprayup and compression molding with robotics and fast-cure PUR resins. Magna demonstrated the process in a pre-production hood with a Class A surface, using a paper honeycomb core and carbon fiber fabric or glass mat faceskins sprayed with resin and cured in a heated tool and compression press. The cured part was demolded, trimmed and placed again in a compression mold, where vacuum resin injection molding (RIM) added an outer PUR skin for Class A finish (see Learn More). The two-step process was completed in 8 minutes, and the part was painted offline.

Modularization and multifunctionality

Already a trend in the 1990s, Tier 1 suppliers continue to advance their ability to integrate parts and deliver complete front end, roof, door and tail/liftgate modules. One example is Magna's all-thermoplastic (and recyclable) tailgate for the 2014 *Rogue* crossover utility vehicle (CUV), which combines a painted thermoplastic polyolefin (TPO) outer with a molded-in color, 30% reinforced LGF PP inner. The module includes tail light system, rear window, electronics and spoiler into a single unit, delivered to the Nissan assembly line, reducing space, workers and time for the OEM. The part also cut weight 30% vs. stamped steel and claimed a 35% lower-cost outer vs. SMC due to reduction in and reuse of scrap.

Plastic Omnium's *Higate* composite tailgate integrates lights, antennae, motorization and crash protection at low cost and 25% less weight than steel, as fitted to the Peugeot *308*. A variant prototype switched the SMC from glass to carbon and, despite adding aerodynamic spoilers and side deflectors, still cut weight 10% vs. an aluminum

LEARN MORE

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

Read CW guest columnist David White's excellent summary, "SMC resin and primer advances prevent paint pops" | short.compositesworld.com/Yv0eFO1y

Read "Innovation driving Automotive SMC" online | short.compositesworld.com/InnoSMC

Read online about HP-RTM processing of thermoplastics and thermosets in "HP-RTM on the rise" | short.compositesworld.com/RTMup

Read online about Katcon's acquisition of CSM technology in "Processing within the PUR cure window" | short.compositesworld.com/PURinauto

design (Fig. 2, p. 31). Polotzki agrees with the benefit of SMC in this type of integration, adding, "We are working with several OEMs and Tier 1 suppliers as they develop new products using SMC for decklids and roof modules because it enables radiolucent parts with antennas embedded," says Polotzki.

In its December 2016 *Investor Day* presentation, Plastic Omnium asserted that the future vehicle envelope will be *intelligent*. The company said it will offer a lightweight, smart material body panel system within *five years* (Fig. 3, p. 33), aimed at integrating more functions. The Tier 1 supplier also will partner with OEMs to develop integration of and efficient architectures for *complex interactive modules*. One function already desired by car owners and demonstrated in a three-year research program is electrical energy storage (see Learn More, p. 34).

Next steps for SMC

Siwajek acknowledges the trend toward body panel multifunctionality, including energy generation and storage, but envisions a longer development timeline. "Embedded circuitry is pretty far down CSP's development pipeline," he cautions, "but we're looking at graphene and other nanomaterials. If we can boost conductivity and get additional functions like energy storage and protection against electromagnetic and radio frequency interference (RFI, EMI), that's great, but we still have to meet Class A and cost requirements." He adds that CSP will pursue these types of developments with an OEM as a partner, noting that such partnering is happening much more often. "We have several projects right now, where OEMs have brought problems to us and we are working together to develop solutions, sharing labs, data and resources."

For the present, the big issue continues to be weight reduction. "The next opportunity for SMC is to further reduce density while maintaining part stiffness," says Polotzki. Ashland Performance Materials (Columbus, OH, US) has released results from new 1.1 and 1.0 SG density SMC product development which show no compromise in surface quality, while Core Molding Technologies (CMT, Columbus, OH, US) is promoting its 0.98 SG Hydrilite SMC. This offers a 17% reduction from its 1.18 SG Airilite and Econolite products. A full Class A version of Hydrilite is still in development. "With an ongoing need for lightweighting solutions, no doubt our customers will continue to request further reductions in density, which we will strive to achieve," said CMT VP marketing and sales Terry O'Donovan. And no doubt the quest to make these work in the Class A vehicle envelope of the future will continue as well. CW

ABOUT THE AUTHOR

CW senior editor Ginger Gardiner has an engineering/materials background and more than 20 years of experience in the composites industry.
ginger@compositesworld.com

Plant Tour: Aeris Energy, Caucaia, Brazil

This young, up-and-coming wind blade manufacturer was founded to serve the Brazilian wind energy market, but it's poised to do much more.

By Jeff Sloan / Editor-in-Chief

» To get to Aeris Energy, you very likely will pass through Fortaleza, a sunny coastal city of about 3 million people located in the northeast of Brazil in the state of Ceará, just a stone's throw south of the equator. From Fortaleza, you'll drive west on Highway 222 for about 45 minutes, and then turn north on to CE-422, which takes you to the Complexo Industrial e Portuário do Pecém (industrial park), just a few kilometers south of the Port of Pecém, one of the largest in Brazil. You will pass an electrical substation, on your left, before approaching Aeris Energy on the east side of the road, readily identified by a large number of wind blades lined up in expansive, open yards next to the facility's largest buildings.

You will park in the lot next to the security station, and as your passport is checked and verified, you notice three things: It is hot, windy and you are, you believe, very far from civilization. It's poor preparation, indeed, for entry into Aeris Energy and the education you're about to receive about its beginnings, the people who work there, the up-close look at its operations and how important this out-of-the-way location is to Aeris, local wind turbine manufacturers and to Brazil.

The wind in Brazil

To understand the genesis of Aeris Energy, you must first understand the Brazilian wind energy industry. The profile of electricity generation in Brazil is unlike that of other major countries. Brazil is the second largest producer of *hydro*electric power in the world (behind China), relying on it for more than 75% of its electricity. Most of the hydropower, naturally, comes from river systems in north and northwestern Brazil, which is far removed from major population centers and thus presents a challenge from an energy transmission and reliability perspective.

To stabilize the hydropower situation, Brazil is constructing the 14,000-MW Belo Monte dam on the Xingu River in northern Brazil, which

FIG. 1 Brazil's wind energy leader

Aeris Energy was formed in 2010 to manufacture wind turbine blades primarily for the Brazilian wind energy market, which is centered in the northeast part of the country. The company's easy access to one of Brazil's largest ports means that Aeris also can serve overseas markets.

Source (both photos) | Wellington Fernandes

will be, when it opens this year, the second-largest dam in Brazil and the third largest in the world. Still, Belo Monte also is far from Brazil's major cities, which are located primarily on its east coast.

The inherent problem of hydropower is its dependence on water. When there's a drought, water flow and energy generation are reduced. The country, therefore, is turning to other resources to help stabilize its electrical energy supply. These include liquefied natural gas, solar and wind power. Wind holds an advantage: During a drought, the generally stiff winds in the northeast region are actually stronger, which makes wind energy complementary to hydropower. Further, the wind turbine manufacturing supply chain in Brazil is mature: The infrastructure and manufacturers are already in place to meet the needs of wind farm development.

This is important because Brazil's state-run national bank, National Development Bank (BNDES), which finances much of the country's wind farm development, stipulates that wind farms funded by BNDES in Brazil must use wind turbines manufactured in Brazil. This demand is designed, of course, to drive internal economic development and job creation, which it has: The Global Wind Energy Council (GWEC) reports that Brazilian wind energy capacity increased from only 29 MW in 2005 to 8.7 GW by year end 2015, ranking it 10th in the world in total installed wind energy capacity. Brazil installed 2.75 GW of wind energy in 2015 alone. Its wind energy sector now employs more than *41,000* people.

Aeris Energy begins

This demand for locally manufactured wind turbine components drove the creation of Aeris Energy. Any wind turbine manufacturer, if it wants to sell turbines into Brazil, must either establish a facility in Brazil, or find a supplier established in Brazil.

Recognizing this opportunity, around 2009, were five relatively young executives who worked for several years in the Brazilian aerospace sector. Each was educated in composite materials, and each had a deep understanding of the technologies and processes required for composites manufacturing. "The wind industry itself caught our attention," says Bruno Lolli, one of the executives and currently planning and process management director at Aeris. "The opportunity to work with clean energy was very interesting to us. It was very important."

Beginning in late 2009 and into early 2010, the five men began to outline the parameters of what would become Aeris Energy. Meeting early in the morning before work at their then-current jobs, and often in the evening after work, they became steadily convinced that their plan had merit. They only lacked what every entrepreneur desperately needs: money.

Fortunately, in early 2010, they connected with an investor who had just sold a company and was looking to put his money to work in the renewable energy sector. Lolli remembers well the investor's response when they presented their business plan: "He said, 'Are you presenting this business plan for other potential »

FIG. 2 Workforce investment pays dividends

Aeris workers prepare a wind blade for infusion in one of the company's several assembly halls. Ceará state, where Aeris is located, offers a low-cost labor force, but Aeris has invested significantly in recruitment and training to help retain a stable and capable employee base.

Source | Aeris Energy

FIG. 3 Strong supplier technical support

Aeris fabricates its wind blades and roots (pictured here) using epoxy resin supplied by Hexion. Hexion bonding paste is used to assemble all blades. Hexion has provided Aeris strong technical and production assistance throughout the blademaker's evolution.

Source | Aeris Energy

investors?' We said, 'Yes, we are.' He said, 'Please stop. My lawyer will prepare some simple term sheets so that we can move forward together.'" Thus began a financial marriage that officially launched Aeris Energy in mid-2010.

The biggest decision the five faced, says Lolli, was where to physically locate the facility. All five men had originally come from the São Paulo area, but they knew, because transportation represents as much as 20% of a wind blade's cost, that their plant had to be located where wind turbines were being installed, in the northeast, where half of Brazil's wind potential is located. Aeris Energy's founders also knew, says Lolli, that access to overseas shipping facilities would be critical to the company's long-term growth, particularly if it ever wanted to reach non-Brazilian markets. Therefore, Caucaia was chosen, and construction began in 2011.

By late 2011, with construction complete, Aeris won its first blade manufacturing contract, with India-based wind turbine maker Suzlon Ltd. This was followed in early 2012 with a contract with Spain-based Acciona and, in late 2012, with WEG (pronounced "vegg"), a Brazilian energy and industrial equipment specialist. The Suzlon contract expired in 2013, but it was replaced quickly by one with Vestas Wind Systems A/S in early 2015, and General Electric (GE) in 2016. Blades made by Aeris range in length from 53.7m to 61.2m.

During this growth period, Aeris went from per annum production of 100 blades in 2013 to 2,000 blades today, operating out of a sprawling 55,000m^2 multi-building campus that employs 2,500 people. The company has become a stalwart employer, a highly respected blade manufacturer and a vital cog in the Brazilian wind energy machine.

The tour

Perhaps it goes without saying, but the sheer size of wind blades makes their manufacture a logistical challenge several orders of magnitude more complex than most composites manufacturing. Quantities of core material, glass fiber fabric, epoxy resin, epoxy adhesive and bagging materials are measured in thousands of kilograms. Molds are long and complex, and the number of employees required to produce a single blade introduces an error potential that makes quality control that much more challenging.

Aeris manages this complexity, and the people within it, by organizing its manufacturing around its customers. So each customers' work is organized, based on the molds dedicated to its blades.

Lolli is *CW's* guide during the plant tour, and our first stop is administration, where the board of directors (the five founders) works alongside employees in human resources, finance, control and contract management. This open-concept work area, says Lolli, fosters communication among managers and the

FIG. 4 Controlling manufacturing and man-hours

An Aeris worker finishes up blade layup. One thing Aeris focuses on closely is the man hours and cost to manufacture a blade. It takes the company about 24 hours to produce a blade, from start to finish. The goal is to reduce that number, without incurring additional labor costs.

Source | Wellington Fernandes

FIG. 5 Kitting, cutting … and controlling scrap

Workers in the cutting and kitting building prepare peel ply kits. In the background is the Eastman Machine cutting table used to cut glass fiber fabric. Aeris pays particular attention to development of kits for each blade type it manufactures. The goal is to make sure that the scrap rate of dry fiber and consumables is kept to an absolute minimum.
Source | Wellington Fernandes

rank-and-file, and puts the five founders in direct proximity to day-to-day operations of the plant.

Next stop is the GE/WEG building, featuring three 56.9m GE molds and one 53.7m WEG mold. We enter the building from the middle of its long side and find the largest molds, for the wind blade shells, lined up one after the other along the left side of the facility, each fully open, surrounded by workers and in various states of being laid up with dry glass fiber fabric and core material, including balsa and foam (Figs. 2-4, pp. 37-38). Some ply and core placement is guided by overhead lasers. Each mold is a clamshell construction, comprising two halves connected by massive hinges.

On our right, across from each mold, are smaller tools, used to fabricate the corresponding shear webs and spar caps, and these are also being laid up. It is obvious, looking at the molds, that the architectures and material selection for the turbine manufacturers' blade designs vary. Where and how core and glass are applied is readily apparent. Similarly, shear web and spar cap designs also differ significantly.

Once layup of each blade half is complete, spar caps are placed in each half, and then the entire mold is bagged for resin infusion. The molds are heated and full cure takes about a day, says Lolli, but the blades usually can be bonded within 4-5 hours of infusion, followed by demolding. Aeris, he says, carefully controls mold temperature and manages exotherm closely.

When infusion is complete, the molds are prepared for shear web attachment. The shear web, which runs about 90% of the blade's length, is a large composite structural beam that is attached to and works with the spar cap to stiffen the blade and carry bending loads. The three primary blade components — shells, spar caps and shear web — are critical not only to blade function, but also blade longevity. Each must meet closely managed specifications to provide optimum wind turbine performance, says Lolli.

Passing through the building, we see an overhead crane transferring a shear web into one of the GE mold halves. Workers are carefully positioning the web onto adhesive attachment points in the mold on the spar cap to ensure precise location and fit. After we leave, workers will apply bonding paste to mating points of the mold half with the shear web. Then, the mold half without the shear web attached will be closed over the half with the shear web, thus completing blade fabrication.

As we leave the GE/WEG building, we notice, in the facility's midsection, between the blade molds and the spar cap/shear web molds, the blade root molds. Oriented with the blade-mating side facing the blade molds to permit easy attachment with minimum effort, each is being laid up and infused, to coincide with its blade.

Adjacent to the GE/WEG building is the newest structure on the Aeris campus, where Acciona's blades are laid up — at 61.2m, the longest Aeris manufactures. During our visit, this space was being reconfigured to accommodate mold reorganization. Aeris »

SIDE STORY

Aeris Energy factoids

- Location: Caucaia, Brazil
- Facility: 45,000m^2
- Employees: 2,000
- Customers: GE, WEG, Acciona, Vestas
- Molds: 10
- Blades/year: 2,000
- Glass fiber: Owens Corning, SAERTEX, CPIC, Gammatensor
- Epoxy: Hexion, Olin Epoxy
- Certifications: ISO 9001:2008; ISO 14001; OHSAS 18001; NBR 16001
- Blade length limit: 70m
- Fraction of wind blade cost assigned to transportation: 20%
- Fraction of wind blade cost assigned to materials: 70%
- Wind blade materials: Glass fiber, 50%; resin, 35%; core, 5%; adhesive, 3%; coatings, 2%; bolts, 5%
- Fraction of Aeris wood, plastic, metal waste recycled: 27%
- People per shift devoted to mold maintenance: 10
- Average mold life: 500-1,000 blades
- Mold weight: 8-11 MT

FIG. 6 Adhesive bonding a top priority

Hexion's bright green RIM BP535 bonding paste is ubiquitous throughout the Aeris facility. It's favored because it offers low density, high toughness, low sag, spreadability and long pot life. Source | Wellington Fernandes

is building another structure like it. Two more WEG molds and the Acciona molds will eventually be moved to these spaces.

Cutting, kitting, resin

Next stop is the cutting and kitting building, where glass fabric, peel ply and infusion bagging film are cut and kitted for all non-Vestas wind blade assembly. The room is dominated by a large 10m-long Eastman Machine (Buffalo, NY, US) automatic cutting table for the cutting of glass fiber fabric and, next to it, a 25m long table for manual cutting of peel ply and film (Fig. 5, p. 39). Glass fiber fabric is delivered to this room from the warehouse on large rolls. Glass used here includes fabric from Owens Corning (Toledo, OH, US), SAERTEX (Saerbeck, Germany), CPIC (Chongqing, China) and Gammatensor (Alcoy, Spain). Owens Corning materials are supplied from Rio Claro (São Paulo, Brazil). Saertex materials are supplied from Indaiatuba (São Paulo or Huntersville, NC, US). Cut plies come off the table, are immediately re-rolled by workers and then stacked on pallets and prepared for delivery to molds.

Lolli says that one of the challenges of molding large blades from large molds is dimensional accuracy. Even the very best molds made to the highest standards are unlikely to match, exactly, the plies in the as-designed layup schedules. Thus, it is also unlikely that plies cut to design spec will lay up without some gaps or overlaps. Because of this, kit development for each blade

SIDE STORY

Wind blade economics

One result of Aeris Energy's close relationship with resin supplier Hexion (Columbus, OH, US) is that the former has embraced much of the latter's strategic and operational thinking. Hexion's wind energy and composites team, led by Johannes Meunier, Hexion's global segment leader, wind/composites, has been a steady, influential presence at Aeris almost from its start.

Meunier and his team, based out of Germany, have a long history with composite materials, composites manufacturing and the wind energy industry. Because of this, he has seen good and efficient as well as bad and *in*efficient composites manufacturing. In short, he has firm opinions about what it takes to maximize efficiency, quality and profitability in the wind blade manufacturing space.

Meunier notes, first, that the wind blade manufacturing industry has matured substantially in the past decade. Product quality standards have tightened, material quality has improved, manufacturing processes have been fine-tuned, blade architecture has evolved, average blade length has increased, and blade lifespan expectations have lengthened — to 25 years. Unchanged, however, is the fact that the blade is the bottleneck in the overall wind turbine manufacturing process. Blademakers, therefore, are under constant pressure to increase the pace of manufacture, without failing to meet quality and cost targets. Compounding this challenge is the famous Square-Cube Law, which says:

- Wind turbine power is proportional to the square of rotor diameter, and . . .
- Wind blade mass increases in proportion to the rotor diameter cubed.

What does this mean? In prractical terms, wind blade *mass* increases at a greater rate than wind turbine power as rotor diameter increases.

Meunier, therefore, has a few simple rules for coping in this environment. First, emphasize quality and value over unit price. Or more simply, you get what you pay for.

Second, and conversely, don't choose materials based on low unit price. Very often, Meunier says, the use of a more expensive, higher quality material (glass fiber, resin, bonding paste) can provide long-term savings that more than offset the additional cost of the material.

Third, he says, *capture data*. Good manufacturers *value map* — that is, they measure every manufacturing activity and know intimately what it costs in money, personnel and time to manufacture a blade. Among the things to measure: In-mold repairs, raw material cost and waste, resin used vs. resin disposed of, blade manufacturing time, man-hours per blade, cycle time and kitting accuracy.

Fourth, continuously improve. Use your captured data to feed a continuous effort to increase manufacturing speed and workflow *without* increasing personnel costs. Look for wasted time, effort, material and money, and then work to get rid of it. "The customers that see that potential are the most successful customers," Meunier contends. "You cannot achieve such savings by pushing down on unit price. You must innovate the cost out."

This philosophy is expressed clearly at Aeris in many ways — in how the company manages its workforce, cares for its molds, carries out production, and positions itself in the marketplace. "We do not make the least expensive blades," admits Bruno Lolli, Aeris' planning and process management director. "That is not how we compete. But we make quality blades, and we focus on serving the customer. We feel we are in a very good place."

FIG. 7 **Ensuring blade surface aerodynamics**

Wind blade finishing at Aeris includes filling, sanding and painting. Source | Aeris Energy

FIG. 8 **Timely service from a talented technician**

Johannes Meunier, Hexion's managing director, global segment leader, wind/composites, speaks to Aeris employees about the importance of leading-edge integrity in wind blade manufacture and operation. Hexion has been a valuable technical resource in Aeris' maturation.

Source | Wellington Fernandes

design is, upfront, an exacting, time-intensive process that, ultimately, ensures that Aeris' blades meet spec with minimal waste.

To start, Lolli says, when a mold is delivered, the first plies are cut to a size a little bit larger than print. These are placed in the mold and trimmed by hand to fit the geometry of that specific mold, with no gaps or overlaps. These plies then become the new masters for that mold and are used to program the recipe in the cutting table software. The goal, notes Lolli, is to deliver kits to each mold that are complete and precise. "Material coming into the kitting room is in a form we cannot control," he says. "When it leaves here, it must be perfect. The production hall is an assembly line, not a manufacturing line."

From the cutting and kitting building, we venture outside toward Aeris' resin storage facility — a massive walled, roofed shed, vented to the outside with large, windowless openings near »

NEED TO INCREASE TOOL LIFE AND PART QUALITY?

Visit www.onsrud.com for more information

LMT Onsrud's CVD Diamond-Coated solid carbide cutting tools optimize performance when machining composite materials.

- **Multi-Flute Composite Routers**
- **Low Helix Rougher Finishers**
- **Low Helix Cutters**
- **Composite Drills**
- **4 & 6 Flute Compression Spirals**

LMT Onsrud LP
1081 S. Northpoint Blvd
Waukegan, IL 60085
Phone 800 234 1560

LMT • ONSRUD

TAKE IT ON

FIG. 9 Turbine-ready product, prepped for travel

Finished blades are lined up at the Aeris facility and prepared for shipment. Aeris manufactures about 2,000 blades per year for turbine manufacturers WEG, GE, Acciona and Vestas.

Source | Wellington Fernandes

the roof line. Inside, stacked almost to the ceiling, are hundreds of epoxy containers, and several of adhesive bonding paste.

Most of the epoxy resin, and all of the bonding paste used at the Aeris facility is supplied by Hexion (Columbus, OH, US). The resin is Hexion's RIM 035C, designed for infusion and used for all non-Vestas blades. The bonding paste originally supplied to Aeris was Hexion's RIM BP135G3, but that is increasingly being replaced by the new RIM BP535, which Hexion says offers better exotherm properties and much improved mechanical properties (Fig. 6, p. 40). For the occasional hand layup and repair work that must be done on blades, Aeris uses Hexion's HLU L135 resin system.

Hexion's presence at Aeris is substantial and longstanding. Indeed, Lolli credits the resin supplier with not only providing material that does the job, but in helping the blademaker optimize and improve its manufacturing operations all around. Hexion not only built a resin manufacturing facility in Itatiba, Brazil, to serve Aeris and the rest of the domestic market, but Hexion personnel are routinely at Aeris to provide technical and other assistance. "Hexion's support has helped us be competitive," says Lolli. "It is a partnership we have with Hexion, and not just in a commercial sense."

Finishing

After they are laid up, infused, bonded, assembled and have their roots attached, all non-Vestas blades are transferred to the finishing building for painting prep (Fig. 7, p. 41). Here, workers

conduct nondestructive testing, assessing, in particular, bondline quality. Lolli says that about 90% of all blade failures can be traced to bond failures, so Aeris must check every bondline against design allowables, and then decide if remediation is required. “Rework is very expensive,” Lolli notes. “Not to deliver the product is the most expensive.”

Workers in the finishing building also remove excess paste from the bond lines, fill in small holes in the blades, adjust and trim the root, attach an aluminum tip at the end of the blade, and sand the entire surface of each blade skin. Each blade is then transferred to a massive booth to be painted. This is the noisiest, smelliest, dustiest, dirtiest process that Aeris performs, but it is vital to creating a blade surface that, when installed on a turbine, most optimally captures wind energy.

It is in the finishing building that Lolli pauses at the tip of a finished wind blade. He points out the unique curvature of the blade as we look down its length, and he emphasizes the importance of a strong adhesive to maintain blade integrity. Our tour is joined here by Johannes Meunier, Hexion’s global segment leader, wind/composites, who is a member of a larger technical team from Hexion that has provided critical technical support to Aeris as it has developed its wind blade manufacturing (see the Side Story, “Wind blade economics” on p. 40).

Meunier points (Fig. 8, p. 41) out that the leading edge, particularly near the tip, is the part of the blade most subject to abuse in service. On a turbine with blades 56.9m long, rotating at 15 rpm, tip speed is 200 mph/322 kmh. Even half way along that blade, rotational speed is 100 mph/161 kmh. That leading edge, therefore, is being impacted at high speeds and quickly eroded by dust, insects, hail and a variety of other materials. Protection against that erosion is a massive challenge for any wind blade manufacturer, Meunier says. And it’s a problem not yet solved.

Vestas operations

Notably, Aeris Energy’s facility is the second in the world at which Vestas allows its blades to be manufactured by a non-Vestas entity. In fact, the wind turbine manufacturer is famous for the stringent control is exerts over its manufacturing operations. Thus, Aeris must make Vestas blades to the same exacting standards Vestas maintains in its internal operations.

All Vestas operations — cutting, kitting, molding, assembly, finishing — are confined to one building. And there, everything is done to the Vestas spec, as if it were done by Vestas itself. To accomplish this, Aeris sent teams of employees, for weeks at a time, to the Vestas blade manufacturing facility in Windsor, CO, US, where they learned Vestas production standards and practices. In addition, Vestas placed in the Aeris plant two employees of its own to oversee operations.

Cutting and kitting, as with non-Vestas blades, is done on another large Eastman Machine cutting table. »


Used as an alternative to sanding and painting


Used between a mold and a carbon-fiber composite


Used as peel-ply on molds

DeWAL PTFE Tapes & Films — for tighter vacuum seals and cleaner mold separation.

DeWAL’s pressure-sensitive PTFE tapes and films are known for tightly sealing carbon-fiber composites and cleanly releasing parts from molds.

Use them to separate epoxy resins from laminates or to seal vacuum bags up to 500°F.

DeWAL PTFE tapes and films offer minimal elongation and temperature-resistant silicone-based adhesion. UL-recognized 204-HD films are both skived and tensilized for higher tensile strength, lower elongation and higher dielectric strength. 204-HD films range from 0.5 to 21.5 inches wide and are as long as 108 feet, with tensile strength up to 13,000 psi at 500°F. They are in stock in 2, 3 and 5 mil thicknesses, as are other 36” width DeWAL tapes and films for composites.

Whether you are doing open or closed molding, whether your process is lay-up, compression molding, resin transfer or continuous lamination, DeWAL will share a solution with you.

DEWAL INDUSTRIES, INC.
Quality of Product...First

15 Ray Trainor Drive
Narragansett, RI 02882
www.dewal.com usa1@dewal.com
800-366-8356 (International: 001-401-789-9736)

On the production floor, Aeris runs four Vestas-made molds, making 54m blades for the Vestas V110-2.0MW turbine. Lolli says it takes Aeris about 24 hours to make one Vestas blade, with three blades per day coming off the floor. Highly engineered, each features a five-piece shear web and a pultruded carbon fiber spar cap. The result is a highly optimized blade that, at 8 MT, weighs 27% less than other blades of similar length.

While we were in the Vestas production hall, workers had just placed the shear web in one mold half and were in the process of applying Hexion's BP535 bonding paste (bright green) to the mold's mating surfaces. With this done, technicians, supplies and equipment are cleared from the work area, and the other mold half is hinged over and onto the shear web half. It takes about 90 seconds for the mold to close. Workers then climb into the closed blade and remove excess bonding paste squeezed out when the halves mated.

Talking later about the importance of bonding paste in wind blade manufacturing, Hexion's Meunier notes that BP535's attributes — low density, high toughness, low sag, spreadability and longer working life — can allow wind blade fabricators to eliminate use of the "galactica," a multi-million dollar superstructure typically used to support a shear web on the spar cap and mold shell until the bonding paste cures. This is part and parcel with an overall effort by blade manufacturers and material suppliers to optimize blade fabrication, while not only maintaining, but improving, quality.

Immediately adjacent to the production floor is the Vestas finishing hall, where operations are similar to those in the non-Vestas finishing building: NDT, filling, sanding, painting. One difference: Vestas tips its blades with copper, instead of aluminum.

After a Vestas blade is painted and deemed complete by Aeris, one of the two Vestas employees on site is called upon to inspect and certify that it meets the company's standards. The blade is then transferred outside, ready for shipment (Fig. 9, p. 42).

Human relations

Technical issues aside, one of the biggest challenges Aeris faces, given its location, is finding, training and retaining qualified employees.

Ceará state, like many developing regions, lacks or has a minimum of the education, health care and transportation resources necessary to provide a company like Aeris with a steady supply of able workers. This means that even the most qualified employees — most likely from Fortaleza, an hour away — probably have no access to reliable transportation, and could easily miss work if they or a family member is beset by poor health.

Recognizing this, Lolli says Aeris has invested heavily, first, to recruit and train employees but, second, to create a work environment that provides basic needs for each worker. "It is not hard to manufacture blades fast," Lolli says. "But you must have the right people with the right behavior."

Training at Aeris, Lolli notes, is organized into four tiers, revolving around processes and materials. Employees are expected to complete at least three of those levels. And for employees who have not completed high school, Aeris hires teachers to help them earn their diplomas.

To meet basic needs, Aeris' efforts start away from the plant. Before each shift (the company runs three shifts daily, six days a week), a dozen buses fan out across the region and pick up employees at several designated locations. Once at the plant, before he or she begins work, each employee is given a snack and a drink. This is followed, mid-shift, by a full meal in the company-run and –funded cafeteria.

After they eat, employees can relax, read, play games or nap at the Aeris Living Center, a large, open-air, covered facility that includes a small library. Finally, to maintain employee health, Aeris pays *fully* the healthcare insurance premium not just for every worker, but every worker's family. The company also provides — on site, full time — a nurse and physician. When each shift ends, the same buses return all workers home.

LEARN MORE

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

Lolli says that in 2015 the company evaluated its work environment and position in the larger economy and established three goals it intends to meet: by 2018, be ranked among the 10 best places to work in Ceará; be among the 100 most sustainable companies in Brazil; be among the 1,000 biggest companies in Brazil.

Going forward

Looking to the future, Aeris seems primed for growth, wherever it occurs. The company is already located within 500 km of 70% of Brazil's wind farms, and as long as the Brazilian wind market sustains its growth, Aeris is poised to ride along. If, however, domestic conditions change, or if customers need Aeris' blades outside of Brazil, the company's easy access to overseas markets offers a path to sustainable growth. In the meantime, the company has room to expand, strong investor support, excellent technical expertise, a well-developed workforce and a manufacturing model that emphasizes quality and customer service.

Says one of the Aeris founders, "We are who we are. We work hard, we do good things and sometimes we make mistakes. If we see a problem, there is a chance for us to fix it. But the blades we deliver must work. We can have a problem here. We cannot have a problem at the wind farm." So far, so good. CW

ABOUT THE AUTHOR

Jeff Sloan is editor-in-chief of *CompositesWorld*, and has been engaged in plastics- and composites-industry journalism for 23 years. **jeff@compositesworld.com**

Composites Events

March 6-9, 2017 — Ft. Worth, TX, US
AeroDef 2017
aerodefevent.com

March 13-15, 2017 — Beverly Hills, CA, US
SpeedNews 31st Annual Commercial Aviation Industry Suppliers Conference
speednews.com/commercial-aviation-industry-suppliers-conference

March 13, 2017 — Paris, France
SAMPE Europe Summit 17 Paris
sampe-europe.org/conferences/summit-17-paris

March 14-16, 2017 — Paris-Nord Villepinte, France
JEC World 2017
jeccomposites.com

March 21-22, 2017 — Scottsdale, AZ, US
SPE Thermoset 2017 TOPCON
eiseverywhere.com//ehome/179523

March 26-30, 2017 — New Orleans, LA, US
NACE Corrosion 2017
nacecorrosion.org

March 28-30, 2017 — Sanctuary Cove, QLD, Australia
Advanced Composites Innovation Conference 2017
compositesconference.com.au/composites-conference/

April 4-5, 2017 — Atlanta, GA, US
North American Pultrusion Conference
s1.goeshow.com/acma/PultrusionConference/ereg788292.cfm?pg=home

April 4-6, 2017 — Hamburg, Germany
Aircraft Interiors Expo 2017
aircraftinteriorsexpo.com

April 4-6, 2017 — Detroit, MI, US
SAE 2017 World Congress
sae.org/events/composites-europe.com

April 20-21, 2017 — Montreal, QC, Canada
3rd Int'l Symposium on Automated Composites Manufacturing
concom.encs.concordia.ca/autocomposites_2017/index.htm

April 27-29, 2017 — Orlando, FL, US
Composites Pavilion – American Institute of Architects (AIA) Convention 2017
conferenceonarchitecture.com/expo/

May 2, 2017 — Troy, MI, US
12th Annual AutoEPCON
eiseverywhere.com/ehome/197676?eb=330521

May 10-12, 2017 — Beijing, China
SAMPE China 2017
nasampe.org/events/

May 16-17, 2017 — Stade, Germany
CFK-Valley Stade Convention
cfk-convention.com

May 22-25, 2017 — Seattle, WA, US
SAMPE Seattle 2017
nasampe.org/events/

May 22-25, 2017 — Anaheim, CA, US
WINDPOWER 2017 Conference and Exhibition
windpowerexpo.org

CW June 14-15, 2017 — Rosemont, IL, US
*ameri*mold 2017
amerimoldexpo.com

June 20-22, 2017 — Chicago, IL, US
The Future of Composites in Construction
jeccomposites.com/events/the-future-of-composites-in-construction-2017

July 4-7, 2017 — Bologna, Italy
3rd International Conference on Mechanics of Composites (MechComp 2017)
events.unibo.it/mechcomp3

July 17-20, 2017 — Ottawa, ON, Canada
CANCOM 2017
cancom2017.org

Sept. 11-14, 2017 — Orlando, FL, US
CAMX (Composites and Advanced Materials Expo) 2017
thecamx.org

CW Sept. 19-21, 2017 — Tampa, FL, US
IBEX 2017
ibexshow.com/show-info

CW Nov. 28-30, 2017 — Charleston, SC, US
CompositesWorld's Carbon Fiber 2017
carbonfiberevent.com

The Only Event Dedicated to the Advanced Materials & Processes community.

WASHINGTON STATE CONVENTION CENTER
Conference: May 22-25, 2017 | Exhibition: May 23-24, 2017

Focus on What Matters Most

SAMPE Seattle 2017 isn't your average materials conference. From education and learning from industry experts, to networking, and parties, you'll gain the insights and inspiration you need to elevate your projects and your career.

With an explicit focus on advanced materials and processes, SAMPE Seattle is your destination for the latest technologies and research advancements concerning aerospace & aircraft, defense, manufacturing, and more!

www.sampeamerica.org

sampe North America

RUSSIAN ORTHODOX CATHEDRAL IN PARIS TOPPED WITH COMPOSITE DOMES

Infused, multi-piece molded sections formed finished domes that reduced dead load on the final building structure by 80%.

When then-president Dmitry Medvedev signed a deal on behalf of Russia in 2010 to purchase a prized and sought-after Unesco-protected property near the Eiffel Tower in Paris to build a large Russian Orthodox cathedral complex, it caused a considerable controversy. This was due, in part, to concerns about the property's sale to Russia and its proximity to sensitive French government buildings, but ultimately to its decidedly unorthodox original design, which was ridiculed in the French press until its withdrawal.

A new team, including architect Jean-Michel Wilmotte, French contracting giant Bouygues (Paris, France) and engineering consultants Calcul Méca (Nantes, France), was assembled and a new design put forward. Composites manufacturer Multiplast (Vannes, France), part of Groupe Carboman, got the nod to fabricate the five gilded domes that, in the revised plan, would crown the Sainte-Trinité Cathedral's roof in traditional fashion, topping off a more muted contemporary visualization (see bottom photo).

The central dome, the largest, is 12m high and 12m in diameter. Composites were a necessity here, says Multiplast, to significantly reduce building dead loads — each composite dome is one-fifth the weight of a conventionally constructed dome.

Sicomin Epoxy Systems (Châteauneuf les Martigues, France) supplied the package of resins and reinforcements for molds and parts. Tooling was produced by **Décision SA** (Ecublens, Switzerland), one of the companies within Groupe Carboman. Décision infused a set of multiaxial glass fiber/balsa-reinforced molds, using Sicomin's SR8100/SD7820 (120°C T_g) epoxy infusion system. Multiplast produced the parts using Sicomin's SR8100/SD4772 epoxy infusion system and a heavyweight quadraxial glass fabric (QX1180) combined with a woven 500-g/m² glass fabric, which eliminated print-through and provided resin flow characteristics that reportedly prevented dry spots.


Source | Sicomin


Source | *Wallpaper* magazine, Augusto Da Silva, Agence Graphix

Guillaume Kemlin, a Multiplast engineer involved with the project, says the decision to produce the domes off site at the Multiplast facility created challenges but ultimately significantly shortened the project schedule and yielded great benefits. "The domes were too large to transport in one piece, so road width forced us to produce the domes in segments 4m wide," he notes. "We utilized our digital tools to the maximum, producing the large dome in 13 segments and the four small domes in four segments." But Sicomin could carry out extensive differential scanning calorimetry (DSC) testing in its laboratory to optimize the epoxy cure profile, ensuring dimensional stability of the finished parts. And after demolding, craftsmen were able to apply 86,000 leaves of real gold to the five domes' segments (a 640m² total surface area) under controlled conditions — a task nigh impossible at the job site. The segments then were transported to Paris for assembly on site.

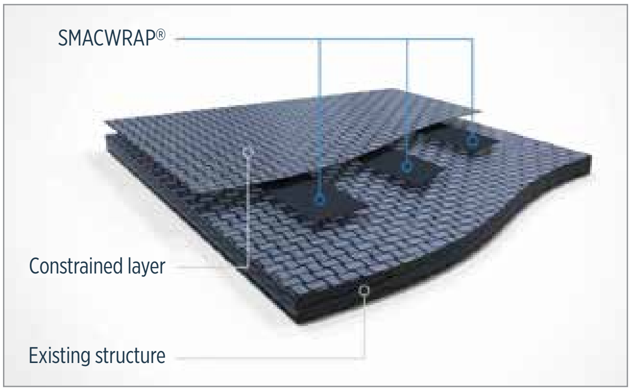
The main dome was installed in March 2016 in the presence of religious and political dignitaries, and the facility officially opened on Oct. 19, 2016. CW

New Products

» NOISE, VIBRATION & HARSHNESS DAMPING MATERIALS

Composite damping material

SMAC, a Toulon, France-based advanced materials supplier, has announced the launch of SMACWRAP, a composite damping solution. SMAC notes that high-modulus and high-strength composite materials tend to be noisy when shocks (even small) occur, and the sound generated with these parts can be uncomfortable and unpleasant. It notes that in air transport, acoustic comfort in aircraft is a major issue for passengers. SMAC's skin-damping principle is based on shearing of a viscoelastic material between two hard layers subjected to vibration. By shearing, specific viscoelastic materials dissipate energy (Joule's thermoelastic effect). One layer is the structure to damp, and the other hard layer combined with the viscoelastic (and the adhesive) material composes the skin-damping product. SMACWRAP is a thin viscoelastic rubber specifically formulated by SMAC and delivered in rolls 60-600 mm wide and 0.2 mm thick. Damping zones must be determined by the designer, and to prevent reduction of mechanical properties, SMAC recommends placing SMACWRAP on top of existing structures, and to cover SMACWRAP with a constrained layer (i.e., with the same Young's modulus as the structure). Reported benefits of SMACWRAP, compared to other damping materials, include vibration, noise and weight reduction, easy application, better crash performance and increased flexibility/anisotropy. **www.smac-sas.com**



» DATA GATHERING/MANAGEMENT SOFTWARE TOOLS

Material and process software updated

Granta Design Ltd. (Cambridge, UK) has enhanced its GRANTA MI materials information management system, its integrated set of software tools designed to give engineering enterprises complete control over how they collect and apply materials knowledge. GRANTA MI:Workflow enables companies to manage materials information and the processes that they require, to ensure that such information can be requested, collected, approved and released in a controlled, secure and traceable manner. Organizations can set up workflows, for example, to ensure that information flows through the system based on an agreed set of steps, and appropriately qualified persons sign off each step. MI:Workflow enables users to implement to-do lists, e-mail notifications, approval sequences, moderation queues and other actions restricted to specified users. It offers a clear user experience for those who consume or contribute to a materials database — they only perform actions relevant to them. Underpinning the system is a Workflow Designer tool and a flexible engine that ensures workflow rules are adhered to, including a Forms Engine for creating tailored user experiences. A key feature of the system, says Granta, is the resulting audit trail — a record of who performed which step of the process, and when. A typical application is processing material test requests, allowing engineers to request test programs, lab managers to schedule and prioritize tasks and a management chain to sign off and release the resulting design data to a wider community. **www.grantadesign.com**

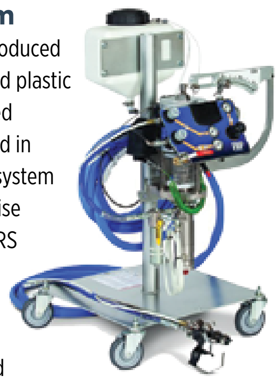
» ADDITIVE MANUFACTURING EQUIPMENT & MATERIALS

Industrial desktop 3D printer

Avante Technology LLC (Cheyenne, WY, US) has announced the commercial release of its new Fabricatus High Precision Desktop 3D Printer. Designed to print tooling for molds as well as precision parts, using proprietary Avante engineering-grade composite filaments, this printer, says the company, is targeted toward tooling and manufacturing engineers who seek to design, build and revise molds and fixtures faster and at less cost than conventional means afford. Capable of 0.05 mm layer thickness at 40 mm/sec, the printer is, says Avante, as precise as many more-expensive, industrial-class printers. It features automatic print-head calibration and a Contour Correction technology that automatically corrects for deviations in flatness of the print bed. The printer also uses dual, fully independent hot ends to provide what Avante claims is a superior way to support printing with *two* filaments on the same print job. Printing support material with the second, independent hot end allows for more precise placement of the material without the risk of one filament "drooling" on the other filament's print path. Unlike twin nozzles on a single carriage, independent hot-end carriages insulate each extruder assembly to facilitate temperature control in each extruder. The hot ends are coordinated to alternate printing of each layer without danger of collision. Each printer comes with two reels of Avante FilaOne filaments (gray and green), two Avante FilaOne printing adhesion sheets, a copy of Avante Emendo automatic .STL file repair software, Slc3r slicing software and Repetier Host printing management software, a putty knife and user guide. Cost of the unit is US$3,750. **www.avante-technology.com**

» SPRAYABLE MATERIALS & SPRAY EQUIPMENT

Gel coat applicator system



Graco Inc. (North Canton, OH, US) has introduced its new, flexible and precise fiber-reinforced plastic (FRP) gel coat system, designed for molded fiber-reinforced plastics, such as those used in automotive applications. Graco's gel coat system proportioner offers what is said to be precise on-ratio dispensing, while the company's RS gel coat gun offers an even and consistent spray pattern and easy maintenance. Features include good ratio stability and control, long-lasting seals and adjustable-ratio catalyst pump. The gun is said to be as much as 44% lighter than competing gun technologies, leading to better handling and spraying control for operators. The gun also reportedly delivers a good spray pattern due to its Air Assist Containment (AAC) technology, which wraps spray in a "containing shield" of air, preventing atomized droplets from escaping the spray pattern. The resulting decrease in overspray reduces material waste and creates a healthier environment for operators. Additionally, the gun's quick-disconnect front end reduces maintenance time, while the needle clamp's design relieves operators from the necessity to adjust needle settings after routine maintenance. **www.graco.com/cwfrp**

THERMOSET RESIN & ADHESIVE SYSTEMS

Styrene-free putty and resin

Discussion of the hazards of styrene, ongoing for decades, has yet to reach a conclusion. Regarded as a hazardous chemical, especially in case of eye contact, but also skin contact, ingestion and inhalation, by the US Centers for Disease Control and Prevention (CDC, Atlanta, GA, US) and the European Chemicals Agency (ECHA, Helsinki, Finland), styrene is listed by the US Department of Health and Human Services' (DHHS, Washington, DC, US) National Toxicology Program (NTP) as "reasonably anticipated to be a human carcinogen" in the *Report on Carcinogens* (12th ed.), despite a preponderance of evidence that indicates otherwise. Nevertheless, interest in styrene-free materials continues to be high in many markets. In response, **Ilpa Adesivi** (Bari, Italy) has developed styrene-free products, including its LINEA BLU line, which includes repair putty for fiberglass, spray putty and polyester resin. The company says that LINEA BLU products are not only safer, but also higher-performing than competing styrene-free products, and are characterized by high adhesion (comparable to epoxy systems) and low volumetric shrinkage on a variety of materials. Nearly odorless, LINEA BLU products are two-component, with a benzoyl peroxide paste hardener and high-boiling methacrylic solvents, and they dry quickly at room temperature. Volatile organic compound (VOC) emissions are lower than 3% w/w (per ASTM 2369). The newer Gluepox cartridge, filled with LINEA BLU mastic and hardener, already dosed, makes for easy application. **www.ilpa.it**

MANUFACTURING SUPPLIERS

VACUUM BAG SEALANTS
Available in various temperature ranges
Used world wide by composite manufacturers
Distributed by:
AIRTECH INTERNATIONAL INC.
Tel: (714) 899-8100 • Fax: (714) 899-8179
Website: http//:www.airtechintl.com
Manufactured by:
GS® GENERAL SEALANTS, INC.
PO Box 3855, City of Industry, CA 91744
800-762-1144 • 626-961-0211 • Fax 626-968-5140
Website: http//:www.generalsealants.com
E-mail: sticktoquality@generalsealants.com

team
Textile Engineering & Manufacturing
Aerospace, Industrial, Marine, R&D
- *Custom 3-D Woven Fabrics*
- *Net Shape Preforms*
- *Specialty 2-D Fabrics/Tapes*
- *Shaped Woven Fabrics*
- *Carbon, Ceramics, Glass, Aramid & Hybrids*

AS9100B CERTIFIED
www.teamtextiles.com
sclarke@teamtextiles.com
(401) 762-1500 • Fax: (401) 762-1580

Concordia COMMINGLED FIBERS
Blended Continuous Filament Thermoplastic and Reinforcement Fibers for Composites
Contact Randy Spencer at
401-828-1100 ext 111 or
rspencer@concordiafibers.com
www.concordiafibers.com

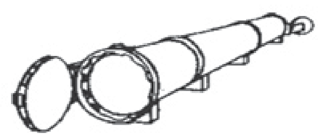
RECRUITMENT/HELP WANTED

www.forcomposites.com
Composites Industry Recruiting and Placement
COMPOSITES SOURCES
Phone (225) 273-4001 • Fax (225) 275-5807
P.O. Box 40086, Baton Rouge, LA 70835
Email: contact@forcomposites.com

Vacuum Tables for Composites
- Work Holding applications
- Eliminates clamps/adhesives
- Reduces set-up time
- Retrofits all machines
- OEMs and Dealers Wanted

Graphic Parts **VacuumTables.com • 773.725.4900**

AUTOCLAVES
New or Remanufactured



Control Systems & Service
Electric, Gas & Steam, High Temp & Pressure
40+ years of world wide installations
AMERICAN AUTOCLAVE CO.
West U.S. **(253) 863-5000**
East U.S. **(706) 692-4480**
www.americanautoclave.com

Diamond and Solid Carbide
- Technical Advice
- Rotary Drills/Routers
- C'sinks/Hole Saws
- Stock and Specials

Designed For Composites
www.starliteindustries.com
800.727.1022 / 610.527.1300

TESTING

Ultrasonic C-Scan Inspection Systems for your High Performance Materials
- Automated Ultrasonic C-Scan Systems for Simple and Complex Geometries
- Multi-Axis Gantries and Immersion Tanks
- System Upgrades

Matec Instrument Companies
56 Hudson St., Northborough, MA 01532 • 508-351-3423
24305 Prielipp Road, Suite 102, Wildomar, CA 92595
www.matec.com
Email: sales@matec.com

ADVERTISING INDEX

SHOWCASE

CINCINNATI TESTING LABORATORIES
A Subsidiary of Metcut Research Inc.

Machining & Testing of Advanced Composite Materials

Comprehensive Testing Expertise
• Mechanical • Physical • Thermal • Enviromental • Fatigue
MMC,CMC, & PMC Experience

Email: info@cintestlabs.com
www.cintestlabs.com
1775 Carillon Blvd., Cincinnati, Ohio 45240
Phone: 800/811-9220 • Fax: 513/851-3336

Cutting Edge Adhesives for Composite Bonding
Designed to meet specific requirements
Resist chemicals, thermal cycling and mechanical shock
MASTERBOND®
ADHESIVES | SEALANTS | COATINGS
+1.201.343.8983 • main@masterbond.com • www.masterbond.com

Carbon composite driveshaft: Tailorable performance

This racing and aftermarket specialist designs and produces custom driveshafts for multiple markets.

By Sara Black / Senior Editor

» Every gearhead knows that the transfer of power from an engine to the axle and drive wheel in a rear-wheel drive vehicle requires a driveshaft, and that this highly loaded part is typically made of steel or aluminum. When composites became more widely available in the early 1980s, carmakers recognized that a carbon fiber composite driveshaft could bring significant benefits unavailable with metal designs, and several production vehicles were so equipped through the early 2000s (see Learn More, p. 55). Nevertheless, OEMs never fully embraced composite driveshafts, due to shifts to front-wheel-drive cars (which don't need driveshafts), four-wheel drive vehicles (which use shorter shafts, for which metals suffice) and the always-present composite/metal cost differential.

Yet, in some corners, composite driveshafts never went away, and there are numerous manufacturers who have prospered making shafts for race cars, hot rods and specialty applications. One of these is QA1 Precision Products Inc. (Lakeville, MN, US), founded in 1993. A specialist in driveshafts, QA1 also turns out bearings, suspension elements and shock absorbers for the full gamut of racing disciplines. "The technology governing composite driveshafts is better today, not just in materials but also in faster manufacturing and assembly," asserts Travis Gorsuch, QA1's director of advanced materials. "Composite shafts offer many benefits."

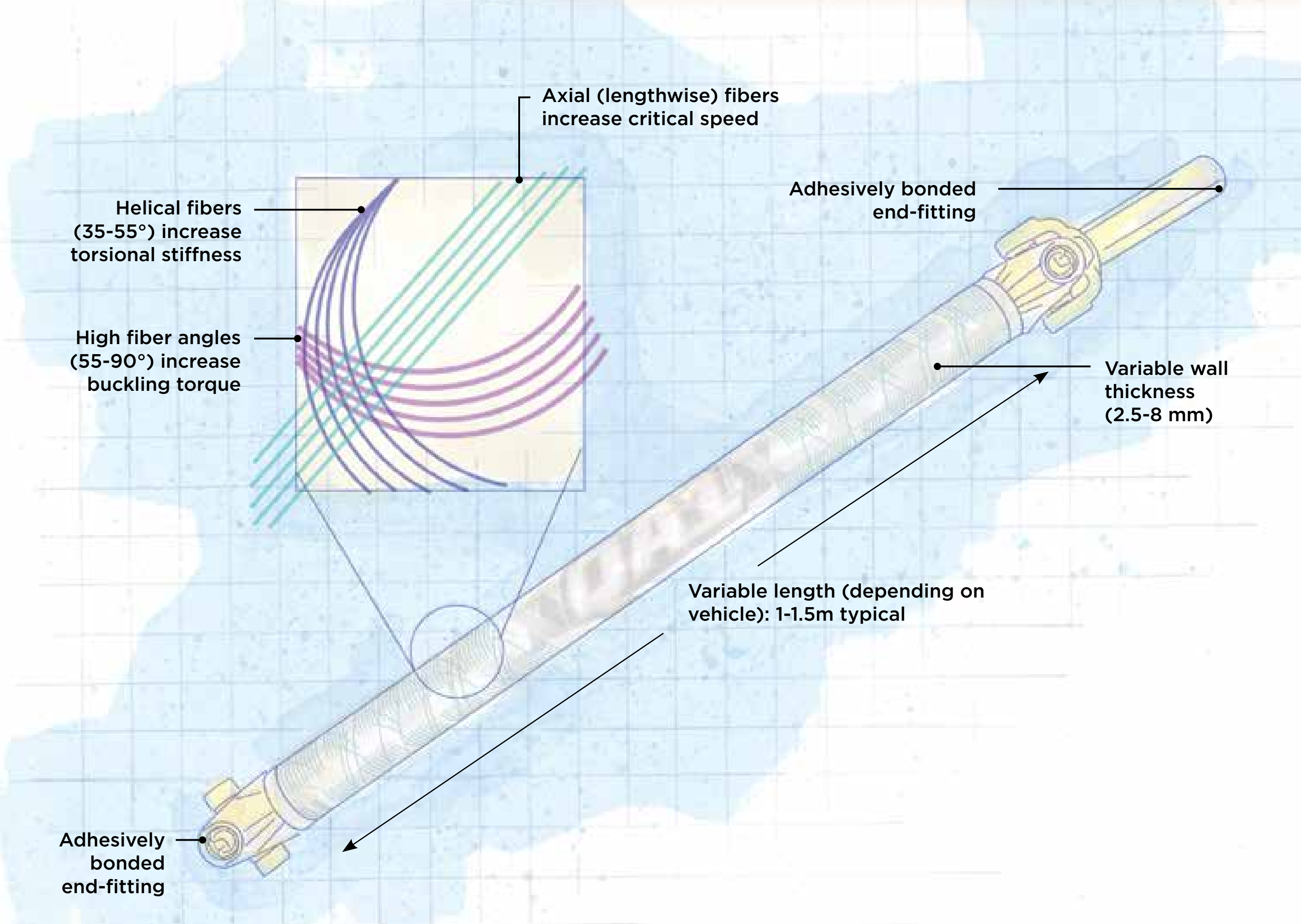
Custom designs for customer applications

In a nutshell, several performance factors interact in driveshaft design. Basically a thin-walled hollow tube, a driveshaft must have adequate stiffness to resist buckling under a specified engine torque output, which might be, for example, 2,500 lb-ft in a high-end, 500-cubic-inch race engine turning at 8,000 rpm. Although the universal joint connections at each end of the driveshaft relieve much of the stress in the drivetrain due to the changing angles, the shaft must perform well because the rear axle constantly moves in relation to the engine. And perhaps most important to the design, the driveshaft must be stiff enough that its natural resonant frequency is higher than that of the engine and the rear axle, so that it does not create destructive resonant vibration. That is, *critical speed* — the point at which the driveshaft's rotational speed and its natural frequency coincide, augmenting vibration to the point of instability — defines the frequency of the first order bending mode. At this point, the driveshaft will undergo amplified displacements, which can cause the shaft to bend or even whip, and ultimately destroy itself. Damping strategies to control first-order vibrations can be employed,

Lighter and stronger than metals

An all-composite, filament-wound driveshaft fabricated by QA1 (Lakeville, MN, US) is commonly three times stronger at half the weight than a metallic version. Custom metallic end-fittings, appropriate to a specific vehicle type, are attached to the ends of the composite shafts in a proprietary 11-step bonding process.

Source (all photos) QA1 Precision Products



DESIGN RESULTS | **QA1 Filament Wound Composite Driveshaft**

- Carbon fiber composite allows customization of shaft's torsional stiffness, axial strength and critical speed.
- Composite driveshafts offer up to three times greater strength at half the weight of those made with legacy metals.
- Nanosilica-enhanced epoxy resin significantly increases shaft longitudinal and hoop stiffness compared to non-modified epoxy.

Illustration / Karl Reque

to take advantage of the higher frequencies between the second, third, fourth and higher resonances.

Gorsuch's team addresses these performance factors with a combination of computer modeling, laboratory tests and in-vehicle, on-track testing of driveshafts, for a range of specific applications. "We look closely at each market and develop specific performance goals, whether it is high critical speed, high torque, weight or perhaps durability, and create custom products for each." He cites the example of QA1's driveshaft for dirt track race cars, for which high buckling strength and durability are overriding concerns. Another product targets street racers who favor much larger engines that produce higher torque, which overpower factory-supplied, two-piece steel driveshafts. Customers also can request a custom-made driveshaft for their specific requirements.

Beginning at square one

To produce a driveshaft, QA1's engineers first input a customer's information — car type, engine type, horsepower and torque, rpm limit, automatic or manual transmission, type of rear suspension setup, and more — into the company's design process. According to Scott Neubauer, QA1's composites engineer for advanced materials, QA1 calculates 12 engineering constants for the thin-walled, tubular driveshaft laminates via a numerical model that is based on a three-dimensional implementation of classical lamination theory. The constants are the elastic moduli (Ex, Eθ, Er), the shear moduli ($G_{x\theta}$, $G_{\theta r}$, G_{xr}) and the Poisson's ratios ($v_{x\theta}$, $v_{\theta r}$, v_{xr}, $v_{\theta x}$, $v_{r\theta}$, v_{rx}).

"Out of these 12 constants, we use the three elastic moduli and three shear moduli to calculate buckling torque, critical speed, » torsional stiffness, and torsional frequency — the latter is a recent addition that is still being validated. All 12 of the constants are used in generating laminate-wide stress/strain responses from various directional loads," explains Neubauer.

The software used for all finite element analysis (FEA) and inertia calculations is SolidWorks Simulation, supplied by Dassault Systèmes SolidWorks (Waltham, MA, US). Says Neubauer, "We also use a numerical model that is implemented in Microsoft Office's native scripting language, Visual Basic for Applications (VBA). This allows us to take advantage of Excel's solvers [Evolutionary, GRG-Nonlinear, Simplex LP] to generate optimized laminates given certain criteria." Modal analysis also is conducted to determine natural frequencies and thus the minimum required shaft stiffness.

Ultimately, the design process produces fiber winding patterns, tube diameter and wall thickness for a customer's specific requirements and performance factors. Although the winding patterns and ply sequence used for each customer or market application are strictly proprietary, generally, the following parameters apply: Axial (0-35°) fibers tend to increase critical speed; helical winding angles of 35-55° tend to increase torsional stiffness; high fiber angles of 55-90° (hoop) tend to increase buckling torque.

A lower winding angle of 20-30° might be chosen if torsional "softness" would be desirable, that is, the shaft would allow a slight axial twist to withstand abrupt power input. "The combination of our design software tools allows us to go through an iterative development process fairly quickly," adds Gorsuch, "and we can design, fabricate and test shafts in a relatively short period, to confirm our computer modeling." He adds that QA1's driveshaft designs are symmetrical with balanced layups, to ensure even stress distribution and balance, with wall thicknesses ranging from 2.5 to 8 mm.

Nanotech for better performance, big benefits

QA1's design efforts, however, go beyond careful attention to the critical reinforcement. "The axial and hoop moduli of a shaft are dependent not only on the winding pattern, but also on the resin matrix modulus," Gorsuch points out, "which strongly affects lamina transverse and shear stiffnesses."

QA1 has worked closely with 3M Aerospace and Commercial Transportation Div. (St. Paul, MN, US) to test and develop a version of 3M's 4831 epoxy, which contains silica nanoparticles, for all of its products. Gorsuch says the nanosilica, added at 30-40 wt/%, significantly increases shaft longitudinal and hoop stiffnesses for a fixed winding pattern, fiber type and fiber content, and it also produces a more durable product with greater abrasion resistance than one made with an unmodified resin.

QA1 typically uses T700 standard-modulus polyacrylonitrile (PAN) carbon fiber from Toray Carbon Fibers America Inc. (Flower Mound, TX, US), but other fiber types are always under evaluation, including those from Mitsubishi Rayon Carbon Fiber and Composites Inc. (Sacramento, CA, US), DowAksa USA (Marietta, GA, US) and Hyosung Corp. (Seoul, Republic of Korea).

Critical: Winding pattern + material selection

The design process considers multiple performance factors to optimize the fiber winding pattern. QA1 employs a modified epoxy resin that contains silica nanoparticles, supplied by 3M Aerospace and Commercial Transportation Div. The additive significantly increases shaft longitudinal and hoop stiffness and delivers higher abrasion resistance, compared to conventional epoxy resin systems.

Wound, inspected and tested with care

Driveshafts are produced on a McClean Anderson-supplied filament winding machine, and oven-cured in-house. Each driveshaft undergoes microscopic inspection, mechanical testing and torsion testing, before delivery.

Market focus: Performance upgrades

An all-composite, filament-wound driveshaft fabricated by QA1 is installed in a performance car, replacing a metal driveshaft.

Gorsuch adds that the company has researched the use of high-stiffness, pitch-based carbon fiber, as well as combining fibers of different moduli in a single part, but, he adds, "while it helps to increase performance, it becomes difficult since it adds manufacturing cost."

After a filament-wound shaft is completed on the company's McClean Anderson (Schofield, WI, US)-supplied filament winding machine, it is wrapped with compaction tape and oven-cured in QA1's custom oven, built in-house for tailorable ramp and dwell cycles. After cure, a shaft is cut to length and a small piece is cut from one end, which undergoes microscopic inspection, using Olympus Stream image analysis software, from Olympus Corp. (Waltham, MA, US), to validate fiber volume, fiber angle and void content. "With this image analysis software, we can verify that the void and fiber volume meet our specifications. In addition, we verify layer thickness and fiber angle," says Gorsuch.

The image analysis inspection is followed by mechanical testing, then metallic end fittings are attached, via QA1's proprietary 11-step bonding process. Next, shafts are torsion tested in house, says Gorsuch: "This is a very vital part of our process, and allows us not only to validate our FEA modeling by showing that a shaft performs as modeled and that simulations are appropriate, but also to ensure the quality of every driveshaft we produce." For specific markets, the testing certifies that driveshafts meet racing quality assurance overseer SFI Foundation Inc.'s (Poway, CA, US) driveshaft specification 43.1. This is followed by a balancing test, to ensure no vibration at operational speeds.

"Our designs are commonly three times stronger than a metallic shaft, and come in at about half the weight," asserts Gorsuch. That alone is a huge benefit: Overall vehicle weight and engine power loss from rotating a heavier metallic shaft are significantly reduced, with no impact on performance. But there's more. From a safety standpoint, the composite will splinter upon impact in the event of a crash, preventing additional damage to the vehicle and its occupants. That's *not* the case with a metallic shaft, Gorsuch adds, which can fail catastrophically. Last, but not least, composites offer better corrosion resistance.

Concludes Gorsuch, "Drivers want more in their cars today, and a lighter driveshaft reduces rotating weight and overall vehicle weight. I believe there's a trend toward greater adoption of composite driveshafts." CW

LEARN MORE

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

Read about a filament wound driveshaft the developers of which hope will qualify for a helicopter application in "OOA: Thermoplastic alternative targets performance spec" | short.compositesworld.com/OOA-TPC

ABOUT THE AUTHOR

Sara Black is *CW's* technical editor and has served on the *CW* staff for 19 years.
sara@compositesworld.com

SIDE STORY

Composite driveshafts in production vehicles

The composite driveshaft appealed first to racing and supercar enthusiasts, to whom performance was paramount and cost was secondary. But the advantages of composites — reduced vehicle weight, greater corrosion resistance and others — overcame the disadvantage of higher upfront cost for a time, among some mainstream automakers as well. A few high-production vehicles well outside the supercar category were equipped by OEMs with composite driveshafts from the 1980s through the early 2000s, including the Nissan *350*, Mazda *RX8*, Mitsubishi *Montero*, and Ford *E100 Econoline* vans.

During this period, there also was a notable hybrid driveshaft design success. From 1986 to 1996, Strongwell (Bristol, VA, US) manufactured the trademarked Spicer Graph Lite driveshaft for customer Dana Inc.'s (Maumee, OH, US) Spicer driveshaft division, starting with General Motors' model year 1988 *GMT-400* pickup trucks.

The opportunity arose, says Strongwell R&D manager Joe Spanovich, because the truck's design allowed a maximum of 100 mm within the chassis for the driveshaft. A full-length, one-piece aluminum shaft had insufficient stiffness, and Dana engineers did not want to install a two-piece steel shaft with a bearing, which would add assembly time, cost and complexity. Strongwell devised a method to pultrude axial carbon fiber tows over an aluminum tube to create a hybrid metal/composite shaft. "Many, many tests were done, severe tests, that took months to complete," says Spanovich. "But it was a lower-risk solution than an all-composite part."

The aluminum shaft, which acted as a traveling mandrel, was first covered with a polyester surface veil/isolation barrier, to prevent galvanic corrosion. Unidirectional carbon fiber tows from Hercules, later part of Hexcel (Stamford, CT, US), were pulled through a resin bath of DERAKANE epoxy vinyl ester (supplied by Dow Chemical Co., Midland, MI, US, a resin later acquired by Ashland Performance Materials, Columbus, OH, US), and laid lengthwise against the veil. The carbon-covered tube then exited through a precision bushing and a winder that wrapped the carbon tows with glass roving. Finally, another polyester veil was placed over the entire shaft, for added corrosion resistance.

The hybrid driveshaft was 60% lighter than the two-piece steel alternative, and saved 9.1 kg per vehicle. The longitudinal carbon fiber tows stiffened the aluminum shaft sufficiently that it could handle vehicle torque without resonant vibrations, says Spanovich. At peak production, the company made 50,000 parts per month. "At that time, we were the largest consumer of carbon fiber in the world," he recalls.

Although early mass-production efforts were largely abandoned and OEMs did not fully embrace them, composite driveshafts are still produced by specialists for race cars, hot rods and other specialty applications.

INSTITUTE FOR ADVANCED COMPOSITES MANUFACTURING INNOVATION

Developing innovative technologies in composite manufacturing

Wind Technology Area Capabilities at the CoMET Faciltiy:

- **Full-scale blade component tooling and fixtures**
- **Rapid prototyping of novel blade materials and production methods**
- **Molding, assembly, bonding, and finishing**
- **Use of segmented 3-D-printed blade tooling**
- **Composite material mixing and dispensing equipment**
- **Simulations and modeling for manufacturing**
- **Structural characterization of coupons, components, and joints**

Wind Technology Area Contact

Derek Berry
303.717.8416
derek.berry@nrel.gov

Become an IACMI Member and Utilize State-Of-The-Art Composite Manufacturing Facilities

The IACMI Wind Technology Area hosted a ribbon-cutting event at The Composites Manufacturing Education Technology facility (CoMET) at NREL's National Wind Technology Center

- The new 10,000-square-foot facility is home to IACMI's Wind Technology Area in Boulder, Colorado and is focused on lowering the cost of wind energy while increasing the reliability of wind turbines.
- Over 150 guests attended the ribbon-cutting event held in conjunction with the IACMI Winter Members Meeting.
- Speakers from industry partners, national laboratories, and the U.S. Department of Energy gave remarks.

IACMI teamed with industry to unveil unique combination of technologies in nine-meter wind turbine blade prototype fabricated at IACMI's Wind Technology Area

"This project is a perfect example of IACMI's strength bringing together partners representing the entire industry supply chain to demonstrate the latest technologies to address cost and performance of composites. Wind energy OEMs are showing great interest in the current research and development work and we anticipate continued collaboration to mature these technologies."

– Bryan Dods, IACMI CEO

Become a member today! iacmi.org/membership

IACMI-The Composites Institute is managed by Collaborative Composite Solutions Corporation (CCS). CCS is a not-for-profit organization established by the University of Tennessee Research Foundation and part of the Manufacturing USA network.

SAERTEX®

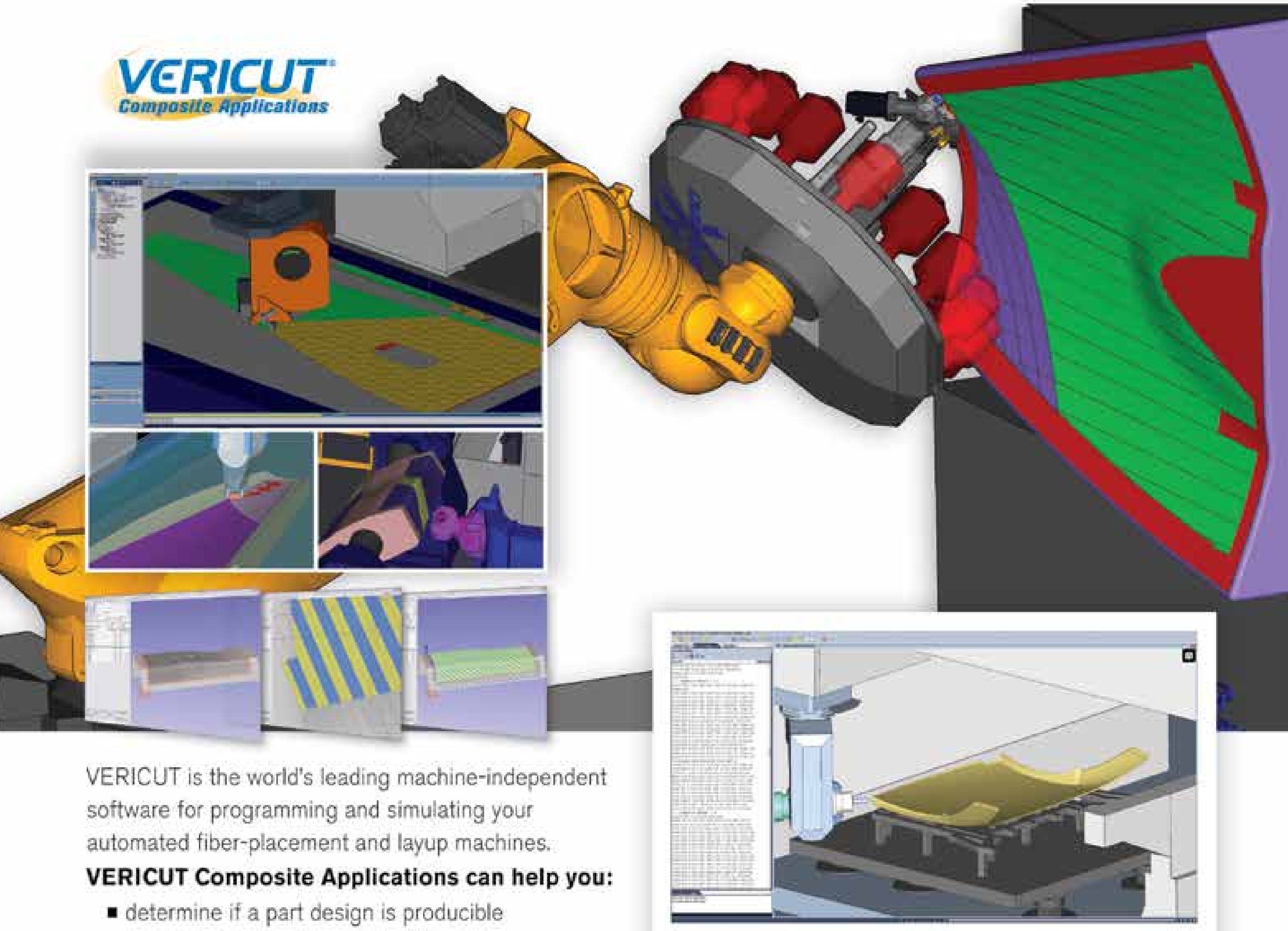
For all whose ideas stretch the limits of today's possibilities: Think Carbon. We are your partner for developing your multiaxial carbon reinforcements. Turn your imagination into reality with **SAERTEX**.

www.saertex.com

REINFORCING YOUR IDEAS

Automating your layup process with CNC equipment?

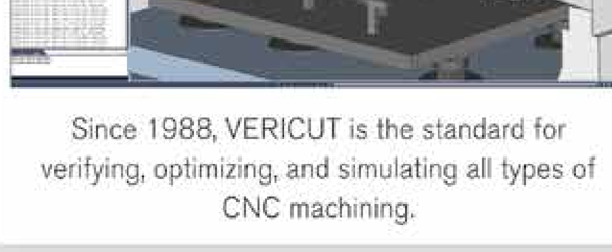
How do you program and validate the process?



VERICUT is the world's leading machine-independent software for programming and simulating your automated fiber-placement and layup machines.

VERICUT Composite Applications can help you:

- determine if a part design is producible
- quickly create NC programs for AFP and ATL machinery
- simulate and analyze NC programs from any system on a virtual machine



Since 1988, VERICUT is the standard for verifying, optimizing, and simulating all types of CNC machining.

Right the first time. Every time.

CGTECH.com