



DOWNLOAD this issue of CompositesWorld in a low-res PDF format — CLICK HERE — Sneak peek of products and services at CAMX 2018 / 18

VR tools guide designs to the real world / 56

Roof rails — thermoplastics displace aluminum / 64



Working with Composites One gives you access to the broadest, deepest line of traditional and advanced composites **PRODUCTS** available – from raw materials, resins and reinforced plastics, to advanced fibers and high-performance solutions – from the industry's top suppliers. Helping you navigate this one-stop-shop and make sure you get what you need, when you need it are technical sales experts and regional customer service reps, along with local support teams at more than 39 distribution centers across the U.S. and Canada. All are backed by the service and support that only North America's leading composites distributor can provide.

That's the power of One – Composites One.



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

TABLE OF CONTENTS

 $\rangle\rangle$

COLUMNS

- 4 From the Editor
- 6 Perspectives & Provocations
- 8 Design & Testing

Dan Adams describes the series of tests used to determine the glass transition temperature of polymer matrix composites.

- 10 Gardner Business Index
- 52 Work In Progress

CW Senior Writer Emeritus Donna Dawson explains the manufacturing process behind monocoque composite bodies on Proterra all-electric buses.









OCTOBER 2018 / Vol: 4 Nº: 10

>> FEATURES

18 CAMX 2018 Show Preview

Held in Dallas, TX, US, CAMX 2018 promises to once again be the largest composites trade show and conference in the world's largest composites market.

By Jeff Sloan

56 Advancing composites through virtual and augmented reality

A review of technologies that are bridging the technical divide between the virtual world of design and simulation, and the real world of composites manufacturing and repair.

By Karen Mason

Inside Manufacturing: Thermoplastic composites: Scenic view

The first use of thermoplastic composite guide rails to replace aluminum brings many benefits to fixed-glass, roller-blind sunroof modules.

By Peggy Malnati

» DEPARTMENTS

- 12 Trends
- 72 Applications
- 73 Calendar
- 74 Ad Index
- 75 Showcase

» ON THE COVER

This GEOStar-3 geosynchronous satellite bus structure, safely cocooned within a custom satellite container, is loaded from a truck into an *Antonov* cargo plane for shipment to its launch location. See p. 76.

Source / Northrop Grumman

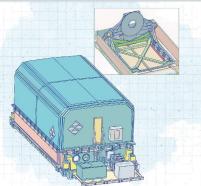


FOCUS ON DESIGN

76 Composite container protects satellite — on the ground

Cored composites add the strength, smoothness and portability needed for a container built to ship satellites over air, land and water.

By Sara Black



CompositesWorld (ISSN 2376-5232) is published monthly and copyright © 2018 by Gardner Business Media Inc. 6915 Valley Ave., Cincinnati, OH 45244-3029. Telephone: (613) 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 #406T2608. The information presented in this edition of Composities/World 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.



CompositesWorld.com





W-I-D-E Films

Vacuum bagging films are available up to 16m (52.5 ft) wide!



- Variety of films available
- Many temperature ranges
- Cost effective
- No seams

Widest in our Industry: Ipplon® KM1300 - up to 9m (356") Ipplon® DP1000 - up to 9m (356") Wrightlon® 7400 - up to 9m (356") Securion® L-1000 - up to 7.1m (280") Securion® L-500Y – up to 8m (315") Big Blue L-100 - up to 16m (630") f 💆 🖸 in 🎯























in f @CompositesWrld

PUBLISHER Rvan Delahantv

rdelahanty@gardnerweb.com

Jeff Sloan EDITOR-IN-CHIEF

jeff@compositesworld.com

Sara Black SENIOR EDITOR sara@compositesworld.com

Ginger Gardiner

SENIOR EDITOR

ggardiner@compositesworld.com

DIGITAL EDITOR

sfrancis@compositesworld.com

ASSISTANT EDITOR Hannah Mason

hmason@compositesworld.com

DIRECTOR, STRATEGIC INITIATIVES Scott Stephenson

> sstephenson@compositesworld.com AND EVENTS

ADVERTISING PRODUCTION MANAGER **Becky Taggert**

btaggert@gardnerweb.com

GRAPHIC DESIGNER Susan Kraus

skraus@gardnerweb.com

MARKETING MANAGER **Chris Saulnier**

csaulnier@gardnerweb.com

CW CONTRIBUTING WRITERS

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

CW SALES GROUP

MIDWESTERN US & INTERNATIONAL Dale Jackman / REGIONAL MANAGER

djackman@gardnerweb.com

EASTERN US SALES OFFICE Barbara Businger / REGIONAL MANAGER

barb@compositesworld.com

MOUNTAIN, SOUTHWEST & Michael Schwartz / REGIONAL MANAGER

WESTERN US SALES OFFICE mschwartz@gardnerweb.com

EUROPEAN SALES OFFICE Eddie Kania / EUROPEAN SALES MGR.

ekania@btopenworld.com

COMPOSITESWORLD IS A PROPERTY OF



HEADQUARTERS

6915 Valley Ave., Cincinnati, OH 45244-3029 Phone 513-527-8800 Fax 513-527-8801

gardnerweb.com

subscribe@compositesworld.com

CHAIRMAN Rick Kline Rick Kline, Jr. PRESIDENT

CHIEF DATA OFFICER CHIEF FINANCIAL OFFICER

CHIFF MARKETING OFFICER CHIEF TECHNOLOGY OFFICER AUDIENCE DEVELOPMENT MANAGER

ADVERTISING AND PRODUCTION DIRECTOR CUSTOM CONTENT DIRECTOR CREATIVE DIRECTOR

EDITORIAL OPERATIONS DIRECTOR STRATEGIC ENGAGEMENT DIRECTOR Dave Necessary

Steve Kline, Jr. Frnest Brubaker Melissa Kline Skavlem **Phil Louis** Julie Ball

William Caldwell Tom Beard Jeff Norgord Kate Hand

GARDNER BUSINESS MEDIA ALSO PUBLISHES

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

OCTOBER 2018 Composites World



September 23-26, 2019: Conference / September 24-26, 2019: Exhibits Anaheim Convention Center / Anaheim, California

www.theCAMX.org

SAVE THE DATE OF SAVE AND A SAVE

CAMX RETURNS TO THE

WEST COAST

PRODUCED BY



OFFICIAL CompositesWorld



>> It's early September as I write this and I am at the Society of Plastics Engineers' Automotive Composites Conference and Exhibition (SPE ACCE) in the Detroit suburb of Novi, MI, US. If you are involved in autocomposites manufacturing, this is a must-attend event, drawing material and equipment suppliers, designers, fabricators, tier suppliers and OEMs from throughout the global automotive supply chain.

I have attended SPE ACCE almost every year since I became editor of CW in 2006. I have seen it weather seriously lean times during the 2009-2011 Great Recession, and I have seen it thrive

This may be the tipping point for autocomposites.

since. I have listened each
year to presentations about
resins, fibers, manufacturing
processes and software solutions aimed at making composites viable for high-volume automotive manufacturing. I have also

heard automotive OEMs declaim what we've all heard are the serious disadvantages of composites: they are too expensive, too slow, too difficult to design, too difficult to model, too different.

For many years, it seemed composites might be perpetually relegated to high-end, high-priced, low-volume vehicles, destined to be purchased by the relatively few owners who could afford these "exotic materials." The composites industry, of course, was not blind or deaf to the criticism leveled at it by automotive OEMs. In response, material and equipment suppliers and fabricators have worked diligently to develop technologies that reduce cost and cycle time. Advanced CAD and CAE programs, snap-cure resins, multimaterial adhesives, low-density SMC, and many other innovations leap to mind.

As a result, three or four years ago, we started seeing evidence of composites migrating into mid-priced, mid-volume vehicles from automakers like BMW and Audi. High-volume vehicles? Gosh, we were told, those same hurdles still loomed — price, cycle time, design inefficiency.

This year, walking the exhibit floor, listening to keynote speakers and taking in technical presentations, I have seen some remarkable things. Take, for instance, this morning's keynote speaker, Mark Voss, engineering group manager at General Motors Co. He described in great detail the six-year development of the carbon

fiber/nylon SMC pickup truck bed for the 2019 GMC Sierra Denali. He described the persistent, creative effort GM and its partners put into development of this first-of-its-kind, highly durable, versatile, tough bed that weighs 62 lb less than its steel predecessor.

Or, consider the Ford Motor Co. front-end module demonstrator on display in the Ashland booth. Covered in the August 2018 issue of *CW*, this structure, made by Magna International in cooperation with Ford, was fabricated with co-molded NCF and SMC, and consolidated 45 parts in the 27.4-kg steel version to just six parts in the composite version. It also reduced weight 34% and, over its life, is a more cost-effective, sustainable alternative. The truth is that you can't walk more than a few feet at this conference and not discover a composite part or structure that proves not just the viability of composites in high-volume automotive, but their sensibility and affordability.

Frankly, any automotive OEM looking to reduce vehicle weight by converting major structures to composites has no shortage of options to do that efficiently. There are just too many fiber, resin and equipment options available to claim that it's not possible. On top of that, the composites industry is replete with subject matter experts who have demonstrated repeatedly that they are more than willing and able to help automakers apply composites successfully. Of course, this is a not a one-way street: The willingness composites professionals possess must be matched by the willingness of carmakers.

This said, I do not mean to imply that all of the woes of autocomposites have been banished. Challenges remain, but if there is an autocomposites tipping point, this might be it.

Yes, composites are complex and atypical and occasionally confounding, and they are not the best material for all vehicle applications. But they are a great option for many vehicle applications, and they are easier to apply today than ever before.

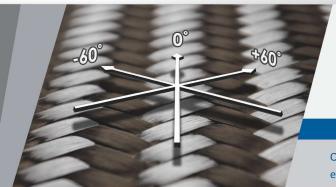
Am I right? Time will tell, and in the meantime, we will continue to help make sure you are up to speed on the always-interesting autocomposites journey.

C/668hm

JEFF SLOAN - Editor-In-Chief

ASP Technology BETTER WITH BRAID

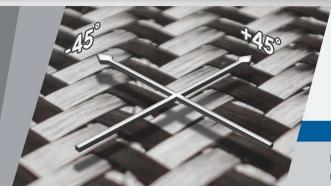
BETTER PARTS. LOWER COSTS.





Quasi-Isotropic Fabric - Balanced in a Single Ply

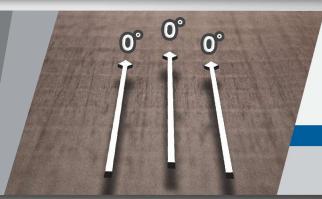
QISO® has the same properties in every direction enabling simple and efficient processing, reduction in waste, and superior performance.





Off The Roll +/-45° Fabric

Bimax® is a biaxial +/-45° fabric offering significant material savings and reduced manufacture time.





Highly Efficient Unidirectional Fabric

ZERO® is an affordable, highly efficient unidirectional fabric offered in a variety of areal weights.



www.braider.com



513.688.3200





4595 East Tech Dr. Cincinnati, Ohio 45245



Composites in infrastructure: IMAGINE that!

>> In late August, Bloomberg Business Week reported that the final eight miles of US Interstate 95, which stretches more than 1,900 miles from Maine to Miami, would open in September, more than 60 years after the law that authorized its construction, the 1956 National Interstate and Defense Highways Act. It is the last stretch of road to be funded under that legislation.

During those 62 years, many of America's roads and bridges have seen significant wear and tear, due to the effects of weather and heavy traffic, with much of this infrastructure having to be rebuilt, shored up or restored. According to the US Department

The IMAGINE Act's purpose is to encourage research and use of innovative materials in infrastructure.

of Transportation, more than 61,000 bridges are currently classified as "structurally deficient" and in need of repair or replacement. The problem is not limited to the US, as

evidenced by the tragic failure of the Morandi Bridge in Genoa, Italy in mid-August that killed 43 people. It is believed that corrosion of the steel reinforcement in the bridge, accelerated by sea air and, ironically, pollution from a nearby steel plant, resulted in the collapse during a heavy storm. Compounding the tragedy is that bidding on contracts to complete repairs to the bridge were in the process of being awarded.

Among the first things we learned about polymer composites is that they have superior corrosion resistance and improved weatherability compared to traditional construction materials like steel, concrete and wood. While the initial installation cost of composites (or composites-augmented solutions) *might* be higher than the incumbent materials and methods, their use reduces overall life cycle costs as composites-reinforced structures last two to three times as long and require less upkeep. Unfortunately, this view has not historically been supported by the government purchasers of infrastructure, with the focus on acquisition cost and hesitance to try new construction materials and techniques.

Until now, perhaps. At the beginning of August, bipartisan legislation was introduced in both the US House of Representatives and the Senate, under the title of the Innovative Materials for America's Growth and Infrastructure Newly Expanded (IMAGINE) Act. As stated, the bill's purpose is "to encourage the research and use of innovative materials and associated techniques in the construction and preservation of the domestic transportation and water infrastructure system." Further goals are to accelerate deployment and extend the service life of infrastructure, a clear tilt toward life cycle considerations. Innovative materials, as defined by the bills, include high-performance asphalt mixtures, geosynthetic materials, advanced alloys and metals, reinforced polymer

composites, and advanced polymers and coatings. A significant amount of credit for the introduction of this legislation goes to the American Composites Manufacturers Association (ACMA, Arlington, VA, US), which has worked tirelessly for years educating legislators on the advantages of composites in infrastructure.

The bill directs the formation of an interagency task force to assess infrastructure standards and identify barriers to the use of innovative materials, followed by a plan to overcome those barriers. It also directs the Department of Transportation to create Innovative Material Innovation Hubs, or research consortia between government labs, industry and universities, for the materials mentioned above. On the polymer composites side, a logical approach would be to extend the remit of the Institute for Advanced Composites Manufacturing Innovation (IACMI) into infrastructure applications, given that much of the supply community is already engaged with that institute.

The act is not limited to standards and research. It goes further, providing co-funding over the next five years of \$60 million annually for innovative bridges spanning more than 50 ft. and \$65 million annually for improved wastewater and drinking water systems. This co-funding should help municipalities or state highway agencies cover the additional initial costs of infrastructure projects incorporating composites, encouraging risk-taking in applying new materials. It will also provide case studies, intended to overcome the current intransigence to deploy composites, spurring market growth. As an industry, we already have a long history of successful applications in infrastructure — albeit not in widespread use — from fiberglass reinforcing rod in concrete structures to fully composite pedestrian bridges and cantilevered pedestrian walkways on conventional bridges, and relined sewers and water systems, supported with newly evolving building codes and specifications.

There is still a long road ahead, as the bills need to clear committee reviews, survive voting in both houses of Congress and be signed into law before the provisions can take place. ACMA is encouraging companies and the public to provide input to Congress to build broader support. Will this legislation be the catalyst that finally overcomes the barriers to composites adoption in infrastructure? One can hope. And *imagine...* cw



ABOUT THE AUTHOR

Dale Brosius is the chief commercialization officer for the Institute for Advanced Composites Manufacturing Innovation (IACMI), a DOE-sponsored public-private partnership targeting high-volume applications of composites in energy-related industries including vehicles and wind. He is also head of his

own consulting company, which serves clients in the global composites industry. 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 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.



DREAM it. DESIGN it. SHAPE it.

shaping your dreams



EXOPRO® AERO products such as our AERO S, STAD & D-REAM represent OSG's top tier of high performance tooling for composite and composite/metal stack solutions. Featuring our patented ultra-fine diamond coating and unique geometries for enhanced performance. Standard or special tooling, OSG designs new and innovative products specifically to shape our customers' dreams.

Glass transition temperature testing of composites

>> Polymer matrix composites (PMCs) exhibit impressive stiffness and strength properties that are commonly attributed to the reinforcing fibers. However, for many important mechanical properties, the polymer matrix also plays an important role. For example, the fiber direction compression strength of a PMC is highly dependent on the polymer matrix material's ability to support the reinforcing fibers and resist buckling under compression loading.

The role of the polymer matrix material becomes apparent when evaluating "matrix-dominated" mechanical properties of PMCs at elevated temperature conditions, at which the stiffness and strength properties of the polymer matrix are reduced. These mechanical properties gradually decrease as the test temperature increases, due to reductions in the polymer matrix material properties. As the temperature of thermosetting PMCs are further

The glass transition temperature of PMCs is determined by a series of tests at increasing temperatures. increased, the polymer matrix material undergoes a transition from the glassy state present at lower temperatures to a more rubbery state. The thermosetting polymer does not melt, but a two to three

order of magnitude reduction in stiffness is produced by this transition from the glassy state¹. Although this dramatic transition takes place over a temperature range, a single temperature typically is specified for a given polymer matrix and referred to as the *glass transition temperature* (T_g).

The glass transition temperature of PMCs can be determined by performing a series of tests at increasing temperatures until a sudden drop in the measured property is observed. Note, however, that a $\it matrix-dominated$ property of the PMC must be measured in which a significant change occurs when $T_{\rm g}$ is reached. Since performing a series of tests at increasing temperatures is time-consuming and expensive, test procedures typically are used in which single specimens are subjected to repeated or continuous loading as the test temperature is slowly increased.

For thermosetting polymers typically used in PMCs, three material properties are commonly measured to determine the glass transition temperature: heat capacity, coefficient of thermal expansion and flexural stiffness. Standardized test methods exist for $T_{\rm g}$ measurement of polymers based on these properties. But how well do these test methods work for fiber-reinforced PMCs?

The first method of T_g determination focuses on changes in the heat required to increase the temperature, or *heat capacity*, of the sample. The use of differential scanning calorimetry (DSC) provides a relatively simple and cost-effective method for determining T_g based on heat capacity changes. This method, described in ASTM D7426², is commonly used for polymeric materials because of the

significant increase in measured heat capacity associated with their glass transition. Since PMCs typically are less than half polymeric material based on volume, however, the change in heat capacity associated with their glass transition is significantly smaller and more difficult to detect using DSC. Therefore, $T_{\rm g}$ determination using DSC is not a preferred method for use with PMCs.

A second property used to determine the T_o of polymeric materials is the coefficient of thermal expansion (CTE), a measure of the dimensional change of a polymer sample associated with a temperature increase. Changes in CTE are used for T_g determination of polymeric materials due to the dramatic CTE increase during their glass transition. Thermomechanical analysis (TMA) methods are used to measure the increase in length of a polymer sample with increasing temperature as described in ASTM E15453. Although expansion TMA is most commonly used for Tg determinations, other TMA methods exist by which T_o determinations can be made while slowly increasing the sample temperature1. Penetration TMA measures the hardness of the sample, whereas flexural TMA measures the center deflection of a beam-like sample loaded in three-point flexure. In both methods, a significant increase in displacement is measured by the TMA probe associated with their glass transition. However, for PMCs, the reinforcing fibers significantly reduce the change in CTE associated with the polymer's glass transition. Additionally, neither penetration TMA nor flexural TMA have received much attention for PMCs. As a result, TMA methods are not commonly used for T_g determination of PMCs.

The third property used to determine the T_g of polymeric materials is the stiffness of a sample under a specified mechanical loading, a logical choice since unreinforced polymers exhibit large reductions in stiffness at their glass transition. Dynamic mechanical analysis (DMA) methods are used to apply an oscillating force to the polymer specimen and measure the resulting displacement as the test temperature is slowly increased. From the measured force and displacement, the specimen stiffness is determined and used to identify the glass transition. Standardized test methods exist for T_g determination of PMCs using DMA for a variety of loading methods, including tension (ASTM D5026⁴), compression (ASTM D5024⁵), torsion (ASTM D5279⁶), three-point bending (ASTM D5023⁷) and dual cantilever beam flexure (ASTM D5418⁸). Procedures calculating T_g values based on DMA testing of polymeric materials are provided in ASTM D4065⁶.

For PMCs, the magnitudes of stiffness reductions at T_g are reduced significantly for many of these loading methods due to the reinforcing fibers. However, significant *flexural* stiffness reductions are still produced, and thus DMA testing of PMCs focuses on flexural loading configurations. ASTM D7028¹⁰ recommends the use of either a double cantilever beam or three-point bend flexural loading. The use of DMA under flexure loading is the most commonly used method for T_g determination of PMCs.

Although the measured T_g establishes a limiting use

Glass transition temperature testing

temperature for thermosetting PMCs, a somewhat lower temperature is typically chosen as the maximum allowable temperature for a particular application. Within the aerospace industry, a material operational limit (MOL) is established by reducing the $T_{\rm g}$ by a prescribed value, typically 28°C / 50°F , below the measured glass transition temperature. Additionally, it is common practice to perform two $T_{\rm g}$ measurements: one without any moisture preconditioning (dry $T_{\rm g}$) and a second using specimens that have been moisture conditioned (wet $T_{\rm g}$). Note that wet $T_{\rm g}$ testing of PMCs is particularly challenging because the specimen tends to lose moisture as it is heated during DMA testing. The use of thicker specimens can help minimize effects of specimen drying during $T_{\rm g}$ testing.

After determining the dry and wet T_g values for a PMC, and establishing an appropriate MOL, it is common practice to perform a series of mechanical tests at the MOL temperature, particularly with specimens that have been moisture conditioned. The resulting "hot/wet" material properties of PMCs often represent a limiting environmental condition. cw

REFERENCES

¹Composite Materials Handbook - 17 (CMH-17), Volume 1, Section 6.6.3: "Glass Transition Temperature," SAE International, Rev. G, 2012.

²ASTM D7426-08(2013), "Standard Test Method for Assignment of the DSC Procedure for Determining Tg of a Polymer or an Elastomeric Compound," ASTM International (W. Conshohocken, PA, US), 2013.

³ASTM E1545-11(2016), "Standard Test Method for Assignment of the Glass Transition Temperature by Thermomechanical Analysis," ASTM International (W. Conshohocken, PA, US), 2016.

⁴ASTM D5026-15, "Standard Test Method for Plastics: Dynamic Mechanical Properties: In Tension," ASTM International (W. Conshohocken, PA, US), 2015.

⁵ASTM D5024-15, "Standard Test Method for Plastics: Dynamic Mechanical Properties: In Compression," ASTM International (W. Conshohocken, PA, US), 2015.

⁶ASTM D5279-13, "Standard Test Method for Plastics: Dynamic Mechanical Properties: In Torsion," ASTM International (W. Conshohocken, PA, US), 2013.

⁷ASTM D5023-15, "Standard Test Method for Plastics: Dynamic Mechanical Properties: In Flexure (Three-Point Bending)," ASTM International (W. Conshohocken, PA, US), 2015.

⁸ASTM D5418-15, "Standard Test Method for Plastics: Dynamic Mechanical Properties: In Flexure (Dual Cantilever Beam)," ASTM International (W. Conshohocken, PA, US), 2015.

⁹ASTM D4065-12, "Standard Practice for Plastics: Dynamic Mechanical Properties: Determination and Report of Procedures," ASTM International (W. Conshohocken, PA, US), 2012.

¹⁰ASTM D7028-07(2015), "Standard Test Method for Glass Transition Temperature (DMA Tg) of Polymer Matrix Composites by Dynamic Mechanical Analysis (DMA)," ASTM International (W. Conshohocken, PA, US), 2015.



ABOUT THE AUTHOR

Dr. Daniel O. Adams is a professor of mechanical engineering and has been the director for 21 years of the Composite Mechanics Laboratory at the University of Utah and vice president of Wyoming Test Fixtures Inc. (Salt Lake City, UT, US). He holds a BS in mechanical engineering and an MS and Ph.D in engineering mechanics. Adams has a combined 38 years of academic/industry

experience in the composite materials field. He has published more than 120 technical papers, is vice-chair of ASTM Committee D30 on Composite Materials and co-chair of the Testing Committee for the *Composite Materials Handbook (CMH-17)*. He regularly provides testing seminars and consulting services to the composites industry.



AOC has the formula for your success.

You can count on AOC for unparalleled innovation — backed by the best quality and service in our industry.





Your Formula for Success RESINS | GEL COATS | COLORANTS

Contact AOC at +01 866.319.8827 or visit us at AOC-Resins.com to learn more.

9 @AOCresins • • + + +

CompositesWorld.com

Composites Index trending lower but still in growth mode

The GBI: Composites Fabricating index broke out of its three-month trend of slowing growth, increasing to 57.7 in August.

>> The GBI: Composites Fabricating index broke out of its three-month trend of slowing growth, increasing to 57.7 in August. The latest readings put the index 1.9% higher than during the same month one year ago. The Gardner Intelligence team's review of the underlying data for the month of August indicates that the Index was pulled higher by production, supplier deliveries and employment. The Index — calculated as an average — was pulled lower by backlog, new orders and exports. August's results marked the third consecutive month of accelerating contraction in exports.

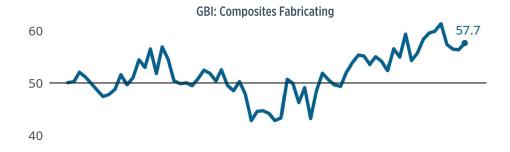
The latest results indicate that production has expanded strongly during the third quarter of 2018. Given the expansion of supplier deliveries and employment in recent months, it is possible that the accelerating replenishment of production inputs is not allowing greater production expansion. The quickening acceleration of production, however, may still not be sufficient to meet total new orders growth as represented by August's backlogs reading, which was the fourth-highest on record since 2013. cw



ABOUT THE AUTHOR

Michael Guckes is the chief economist for Gardner Intelligence, a division of Gardner Business Media (Cincinnati, OH US). He

has performed economic analysis, modeling and forecasting work for nearly 20 years in a wide range of industries. Guckes received his BA in political science and economics from Kenyon College and his MBA from Ohio State University. mguckes@gardnerweb.com



1/13 7/13 1/14 7/14 1/15 7/15 1/16 7/16 1/17 7/17 1/18 7/18

Supplier deliveries and production driving growth

The August Composites Fabricating reading broke the second quarter's trend of slowing growth. Expanding supplier deliveries and production drove the Index's rebounding performance in the month.

GBI: Composites Fabricating — Backlog and Production (3-month moving average) Backlog Production

Strong production still not enough to slow backlogs

Rebounding third-quarter production growth has not been enough to fully offset the growth in new orders. Despite a contraction in export orders, strong domestic orders are generating accelerating levels of backlogs.

1/13 7/13 1/14 7/14 1/15 7/15 1/16 7/16 1/17 7/17 1/18 7/18



Stay ahead of the curve with Gardner Intelligence.
Visit the blog at gardnerintelligence.com or e-mail mguckes@gardnerweb.com

10 OCTOBER 2018 CompositesWorld



INSTITUTE FOR ADVANCED COMPOSITES MANUFACTURING INNOVATION

Closed Mold Alliance Composites Training Workshop



Composites Training Workshop November 14 – 15, 2018

University of Dayton Research Institute Located in Dayton, Ohio

Join us for the next Composites Training workshop at the University of Dayton Research Institute in Dayton, OH, Nov. 14 - 15, 2018.

The workshop is free of charge and is open to those looking to enter the composites manufacturing workforce or enhance composites manufacturing skills. With an opportunity to network with other composites professionals while learning from industry leaders, this workshop is a great opportunity to stay up-to-date with the latest composites innovations.





Learn more and register for workshops at iacmi.org/2018-cma

IACMI-The Composites Institute 2360 Cherahala Blvd

Knoxville, TN 37932

ClosedMold Alliance
Composites One • MVP RTM North Technologies







Become a member today! iacmi.org/membership

TRENDS

A recap of EAA's AirVenture 2018 and Covestro's new fiber thermoplastics products, plus Teijin's acquisition of European Inapal and a bio-based, composite bridge.



AEROSPACE

Personal aircraft and composites at EAA AirVenture 2018

"A 'perfect' event may be unattainable, but AirVenture 2018 came about as close as one could imagine," says Experimental Aircraft Assn. (EAA, Oshkosh, WI, US) chairman Jack Pelton. Given the combination of outstanding programs, aircraft variety, a robust economy and good weather, the week-long event, held July 22-28, attracted approximately 601,000 people, nearly 2% more than 2017's attendee record. More than 10,000 aircraft arrived at Wittman Regional Airport in Oshkosh and other airports in east-central Wisconsin. Wittman alone saw approximately 134 takeoffs/landings per hour. More than 75,000 people attended 1,500 forums, workshops and presentations, some of which involved composite materials and fabrication.

Many of the aircraft at the show were composites-intensive and represent innovative designs and concepts. One of these was exhibited by Terrafugia (Woburn, MA, US, a subsidiary of China's Zheijang Geely Holding Group, which owns Volvo, Lotus, and other international auto brands), founded in 2006. Under its new ownership it is now positioning itself as a major player in the realm of automated vertical takeoff and landing (VTOL) urban air mobility vehicles and "personal on-demand aviation." At the show, it announced major design enhancements for the Transition, its in-development, two-place flying car that flew at Oshkosh five years ago, and also introduced its next transportation concept, a VTOL aircraft for passenger and cargo transport.

First, the existing D2 *Transition* will be replaced soon by a Flight Assessment Vehicle for certification, which will incorporate the enhancements announced at the show. Among these enhancements: road driving power provided by a combination of an internal combustion engine and a LiFePO₄ (lithium iron phosphate chemistry) battery — a safer technology than other lithium battery chemistries, says Terrafugia. In flight mode, a boost feature will be added to the throttle for brief bursts of extra power. A full frame parachute system will also be added.

The company has never given up in its quest for a flying car: "Developing this new technology has allowed us to test several different mechanisms and generate process improvements along the way," says Terrafugia CEO Chris Jaran. "We are at the critical point where we can implement





the best design features based on years of flight and drive testing. This will improve function, safety and aesthetics for the optimal flying and driving experience." The new features will enable the *Transition* to meet all US Federal Aviation Admin. (FAA) and US National Highway and Traffic Safety Administration (NHTSA) safety standards, while optimizing the flight experience for both pilot and passenger. Terrafugia says the first production vehicles will come to market in 2019.

At the show, Terrafugia also introduced an integrated system designed for urban air transportation applications. The *TF-2* consists of a hybrid-electric VTOL aircraft; a ground transportation vehicle; and a passenger (or cargo) pod that can be transported by the ground vehicle or slung under the VTOL. For on-demand people-moving, the concept calls for the ground vehicle carrying a passenger pod to pick up four passengers with luggage and transport them in the pod to a "vertiport," and attach the pod to

AirVenture 2018

the VTOL (within 2 minutes) that will carry them by air to another vertiport. Another ground vehicle will then accept the pod and transport it the last mile to the final destination. *TF-2* will be piloted, and initially have a hybrid-electric drive; all-electric propulsion will eventually be incorporated as the technology matures, says Terrafugia. With a payload of 900-1,100 lb, maximum speed is projected at 120-130 knots and the anticipated range is 170-215 nautical miles.

Samson Motors' (Redmond, OR, US) carbon fiber composite *Switchblade*, introduced last year, was on display again. Company CEO Sam Bousfield announced that, at the show, reservations surpassed the 700 level, so interest is high. Bousfield told the crowd, as reported by David Tulis of Aircraft Owners and Pilots Assn. (AOPA), that the *Switchblade* will fly later this year.

And there were more "personal aviation" vehicles on display. One of these concepts, in its Oshkosh debut, was *BlackFly* (version 2), a VTOL battery-electric personal air vehicle (PAV) by Opener (Palo Alto, CA, US). The odd-looking craft with two wings has already, says the company, logged 12,000 miles in more than 1,400 test flights. A streamlined single-seat cabin with a rounded bottom and glass canopy on top is attached to a forward and a rear wing, with the front wing slightly shorter than the rear. Overall dimensions are 4.2m wide, 4.1m long and 1.5m high. Each wing supports four horizontal propellers, driven by electric motors powered by batteries. Four pairs of elevons

(control surfaces that combine the functions of elevators and ailerons) provide flight control.

Classified as an ultralight aircraft, which means that the operator does not have to obtain a pilot's license, the BlackFly weighs only 313 lb empty, with a maximum payload of 250 lb. The vehicle has a 25-mile range and a 62-mph cruise speed (in the US; European rules allow faster flight). The BlackFly can be recharged via solar panels, which come with the craft's small transport trailer; Opener says an 80% charge is possible in 25 minutes. The vehicle can be disassembled in 30 minutes for ground transport within the trailer, and it is amphibious, with takeoffs and landings possible on water as well as smooth grassy surfaces — no airfield needed. The BlackFlv's light weight is thanks in large part to carbon fiber/epoxy prepreg construction. The company claims that the craft uses 245 watt-hours per mile (wh/mi), compared to a gasoline powered car at 1233 wh/mi, and that noise is comparable or slightly less than the noise made by a typical car or a motorcycle at highway speed.

An interesting video at Opener's Web site shows the craft being flown.

If rotorcraft is your preference, Safari Helicopter (Marianna, FL, US) showed its ultralight class *Safari* 400 and *Safari* 500 helicopter kit-built craft. Safari Helicopter has been in business for nearly 60 years under a succession of names, and its current owners showed at Oshkosh 2018, for the first time, a carbon fiber composite cabin, as an option to replace sheet metal (the cabin frame is chromoly steel tubing). Rotor blades are also carbon fiber composite/extruded aluminum.

Another personal helicopter already familiar to *CW* readers was on display again: the short-hop *Surefly* VTOL craft from Workhorse (Loveland, OH, US). The company's goal is to make *SureFly* safer and more stable than a typical helicopter with redundant design, which includes four folding carbon fiber composite propeller arms, two fixed contra-rotating propellers on each arm, a backup battery system to drive the electric motors in the event of engine failure and a ballistic parachute that safely brings down the craft if needed. The *SureFly*'s fuselage and propellers are made of carbon fiber composites to provide lightweight and durability.

EAA is already looking ahead to the 2019 event, to be held July 22-28, says Pelton. "We are celebrating our 50th consecutive year in Oshkosh during 2019, so we'll be planning activities that involve EAA's hometown and its unique place in aviation history. We're looking forward to announcing features and attractions very soon."



CompositesWorld.com / 13



Basalt Fiber



Basalt Fiber Production is Here in the USA

704.967.8006 mafic.com



CARBON FIBER

Covestro launches Maezio continuous fiber thermoplastics

Covestro (Leverkusen, Germany) has trademarked its continuous fiberreinforced thermoplastic (CFRTP) composite materials as Maezio. Made from carbon or glass fibers impregnated with polycarbonate (PC), thermoplastic polyurethane (TPU) or other thermoplastic resins, Maezio products

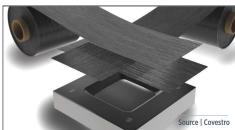
are made as unidirectional reinforced tapes and sheets at Covestro's production facility in Markt Bibart, Germany.

Maezio products can reportedly be thermoformed with existing thermoforming tools at high yield rates and low cycle times for millions of parts per year. Other production technologies such as hybrid injection molding (overmolding), automated UD tape laying and automated fiber placement (AFP) can be easily integrated.

Covestro is offering a range of finishes for Maezio products, from colored and textured, to black and glossy, to matte, untouched unidirectional fiber.

Covestro says the mate-





rial is suitable for use in electronics, automotive, medical, sporting goods, athletic shoes, household appliances, furniture and luggage applications. Maezio products can be recycled at the end of their useful life.

BIZ BRIEF

LyondellBasell (Auburn Hills, MI, US) announced on Aug. 21 it has added **A. Schulman Inc.** (Fairlawn, OH, US), global supplier of high-performance plastic compounds, composites and powders, to its portfolio of polymer solutions.

The combined business will operate as a stand-alone Advanced Polymer Solutions business segment. In addition to LyondellBasell's existing polypropylene compounding (PPC) assets and the A. Schulman assets, the segment will include Catalloy thermoplastic resins (polymers that reportedly combine the advantages of polyolefins and elastomers to offer durable and flexible products for the automotive, packaging and construction industries) and polybutene-1 resins (plastics that offer a combination of temperature resistance and strength and are used in modern water pipes, construction materials and re-closeable packaging).





AUTOMOTIVE

Teijin expands in Europe with Inapal acquisition

Teijin Limited (Tokyo, Japan) announced Aug. 22 that it has agreed to acquire Inapal Plasticos SA (Leça do Balio, Porto, Portugal). Inapal is a Tier One supplier of composite components to the automotive and heavy truck industries. The company's capabilities include Class A body panels, structural and underbody components using a variety of materials and processes, including sheet molding compound (SMC), carbon fiber SMC, prepreg compression molding (PCM), direct long-fiber thermoplastic (D-LFT) and glass mat thermoplastic (GMT). The company has two manufacturing locations in Portugal serving a variety of European OEM customers including Jaguar, Land Rover, BMW, Mercedes, Volkswagen and Bentley.

In addition to its automotive and heavy truck business, Inapal supplies components to the heating and cooling industry, as well as passenger seating components to the bus and rail industries. The company had sales of EUR 31.9 million (USD 37 million) in 2017.

"We are leveraging our lightweight, strong, highperformance materials and integrated composite technologies as one of the key focuses of the transformation strategies for our medium-term management plan," says Jun Suzuki, president and CEO, Teijin Ltd. "The acquisition of Continental Structural Plastics [CSP, Auburn Hills, MI, US] positioned us as a Tier One supplier of high-performance composites to the global automotive market. In July, we announced the acquisition of J.H. Ziegler GmbH [Ziegler, Achern, Germany], a leading supplier of automotive interior materials in Germany. Now the acquisition of Inapal enables us to deliver on our promise to stakeholders to expand our technologies on a global basis, including in Europe. We will seek synergies by leveraging the business capabilities of CSP, Ziegler and Inapal to continue to grow as a supplier of multi-material components. It also enables us to demonstrate our commitment to evolve for future society as an enterprise that delivers new value."

"The addition of Inapal positions CSP well as a global leader in the lightweight composites industry," adds Steve Rooney, CEO of CSP. "With this, we can truly say we are among the world's largest suppliers of lightweight composite components to the automotive industry, we are strategically located to meet our customers' needs, and we're ready for the rapid changes that are taking place in the industry today."



CompositesWorld.com / 15



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

Agility launches new bus and truck systems for India featuring composite cylinders

Agility's Type 4 cylinders are manufactured using carbon fiber composite and are 70% lighter than steel cylinders.

09/9/18 |short.compositesworld.com/agi_india

Luminati Aerospace uses vortex formation to achieve perpetual stratospheric flight

The company's goal of perpetual solar flight would allow them use UAVs to enable internet access to parts of the world that have no access.

09/9/18 | short.compositesworld.com/luminati

Acousti-Cap technology from Hexcel reduces noise in flight test

The company's broadband sound-reducing honeycomb core acoustic liner was recently tested in a joint NASA-Boeing flight test on a B737 MAX test platform.

09/7/18 | short.compositesworld.com/acousticap

Virgin Hyperloop One to open development and testing center in Spain

New 19,000m² center will develop, test and certify components and subsystems to continually improve safety and reliability of hyperloop systems.

09/6/18 | short.compositesworld.com/spain_hype

Seemann Composites opens submarine bow dome production facility

The company has constructed a 25,600-ft² building to produce composite bow domes for the Navy's Columbia Class Ballistic Missile Submarine.

09/4/18 | short.compositesworld.com/submarine

Staufen and Schuler join forces in North America

The two companies have combined efforts to provide consulting services and process optimization for press shops.

09/4/18 | short.compositesworld.com/s_s

AMRC to add ultrasonic assisted machine tool

New composite machine tool will be the first of its size to be fitted with an ultrasonic-capable spindle for use in five-axis machining applications. 09/4/18 | short.compositesworld.com/ultrasonic

Distributed wind market surpasses 1 GW milestone

US distributed wind market has surpassed the 1 GW milestone with 81,000 turbines generating power across 50 states.

08/31/18 | short.compositesworld.com/wind 1GW

Terrafugia expands regional footprint

The company has signed a lease with Nashua Airport for 6,700 ft² of space in preparation for the testing program for the Transition flying car. **08/31/18** | short.compositesworld.com/terrafugia

Orion's final assembly begins

Lockheed Martin have completed construction on the spacecraft capsule structure and have shipped the capsule to Florida for final assembly. 08/30/18 | short.compositesworld.com/finalOrion







INFRASTRUCTURE

Bio-based composite bridge in The Netherlands

This summer, FiberCore Europe (Rotterdam, The Netherlands) joined forces with TU Delft (Delft, The Netherlands) and Schiphol Logistics Park (Schiphol, The Netherlands), and other firms and local agencies, on the design and construction of an ecologically sustainable composite footbridge made with bio-based materials. The bridge is located at the logistics business park in the Dutch city of Rozenburg.

For his thesis at the Bridge Design Group of TU Delft, architect Rafail Gkaidatzis researched bridge designs incorporating the highest proportion of bio-based materials possible. He calls his resultant design "bio-basalt balsa," or B3. The 15m-long, 2m-wide bridge spans the waterway between the Ringdijkpark and the Naritaweg at Schiphol Logistics Park and is publicly accessible by employees of the business park and residents of the adjacent Aalsmeerderdijk neighborhood.

The bridge elements combine basalt fibers from Mafic (Kells, Ireland) and a bio-based polyester resin, based on glycerine-derived glycol. The deck is cored with Baltek balsa supplied by Airex AG, a division of 3A Composites (Sins, Switzerland). Advantages of the composite construction

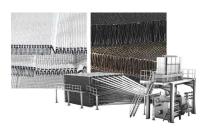


compared to traditional materials are its high strength, low energy requirement during construction, low maintenance requirement and long service life, with no rot or corrosion. As a result, the bridge material is expected to last for at least 100 years.

FiberCore Europe says that the combination of materials, never before used in bridge construction, makes the project unique. It's a step toward making civil construction more sustainable and contributes to the realization of a sustainable society.

The sustainable bridge is the result of the excellent cooperation of all parties involved. Not only technical challenges were overcome, but directors, funders and the client also showed the courage to realize this innovation in deviation from standard procedures.





Take the lead

When it comes to developing and producing innovative textile products for industry, you'll take the lead with highly developed Stäubli solutions for technical fabrics.

www.staubli.com/textile



CompositesWorld.com



What:

2018 Composites and Advanced Materials Expo (CAMX)

Who:

American Composites Manufacturers Assn. (Arlington, VA, US) Society for the Advancement of Material and Process Engineering (Diamond Bar, CA, US)

When

Oct. 15-18, 2018

Where:

Kay Bailey Hutchison Convention Center, Dallas. TX. US

By Jeff Sloan / Editor-in-Chief

>>> North America is the world's largest composites market, and CAMX is the largest composites trade show and conference in North America. Because of this, CAMX 2018 has become the most important composites event on the fall calendar. If you are headed to Dallas, TX, US, Oct. 15-18 for CAMX 2018, what can you expect to find?

To answer that question, the editors at *CompositesWorld* conceived of the CAMX Exhibit Preview, to help show-goers anticipate, in a knowledgeable way, what might be awaiting them when they step onto the CAMX show floor.

As in past years, *CW* polled CAMX exhibitors this year to get a sense of what visitors to the show might find when they walk the aisles in the expansive Kay Bailey Hutchison Convention Center in Dallas. What follows is a summary of some of the previews we received, ranging from fibers, resins and tooling to machinery, software and services.

You can find out more about many of these companies by checking out their listings at the online SourceBook, *Composites-World*'s composites industry supplier directory (www.compositesworld.com/suppliers). Also, the CAMX website offers the MyCAMX Planner, a tool that helps you see and evaluate the

conference and trade show offerings available, and then organize each day to help make sure you see the exhibitors that interest you most. You can use MyCAMX Planner to conduct searches, communicate with exhibitors, make appointments with exhibitors and tag presentations. You can then link this data with the CAMX app on your mobile device to keep your schedule close at hand during the show.

Along those lines, don't forget that CAMX is a conference as well as a trade show. This year's conference features tutorials, technical papers and educational presentations spanning the breadth of the industry, covering additive manufacturing, bonding and joining, design simulation, process technologies, testing and evaluation and much more. A full conference schedule and all other relevant information is available online at the CAMX website.

One final note: We've included booth locations with the previews that follow, but this data can change. For updates on logistical information, not to mention a complete list of CAMX exhibitors, the CAMX conference schedule, Dallas lodging information and — last but, of course, not least — to register for show attendance, visit the CAMX website | thecamx.org.

18

Basalt fiber and parts made of basalt materials

Mafic USA (Shelby, NC, US; Kells, Ireland) is featuring its basalt fiber and strong, lightweight parts made of basalt materials. The company's basalt materials are used in a variety of industries including automotive, construction, insulative, sporting goods and more. Mafic also is scheduled to open its US facility in Shelby, North Carolina in late 2018.



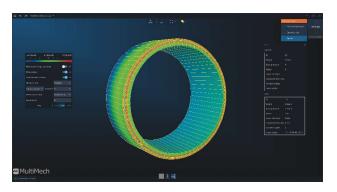
Hybrid 3-axis additive/subtractive machining centers

Diversified Machine Systems (Colorado Springs, CO, US) is featuring its new Hybrid Two³ line of hybrid 3-axis additive/subtractive machining centers as well as its latest, traditional 3- and 5-axis CNC machine centers. The Hybrid Two³ additive/subtractive production process is

designed to integrate traditional milling in intervals between 3D-printed layers. The machine is said to increase efficiency, save time and use up to 90% less material than predecessor systems. The process operates in an enclosed space using conventional, nonhazardous, readily available materials and can be used for the production of tooling, prototypes, layups, fixtures, arrays and ready-to-use parts for aerospace, automotive, marine and other applications. The Hybrid Two3 features a work



envelope that is 2 by 2 by 2 ft. The machines use a dual carriage, which includes an additive deposition head and a 3-axis, 12-HP, 24,000-rpm spindle. Booth S29.



Composite tube and pressure vessel optimization software

Composite modeling and simulation software specialist **MultiMechanics** (Omaha, NE, US) is demonstrating its newly released composite tube and pressure vessel optimization tool. The optimizer combines generic algorithms and the ability to accurately represent microstructural damage within advanced materials to allow for automatic design of high-performance composite tube structures. By eliminating the need to fabricate and test multiple physical prototypes, the optimizer helps reduce the time and cost associated with the development of composite tubes and pressure vessels. It automatically generates models, eliminating the FEA learning curve and pre-processing time to allow for more efficient engineering analysis. Additionally, the optimizer automatically runs multiple simulations based on design constraints, permitting overnight analyses. Booth M44.

Thermoset molding compounds, R&D services

IDI Composites International (Noblesville, IN, US) is featuring its customized polyester/vinyl ester-based bulk molding compounds (BMC), sheet molding compounds (SMC) and an advanced line of Structural Thermoset Composites (STC - Ultra Performance Moldable Composites) that are manufactured in both sheet and bulk formats. Company officials also will be available to discuss the IDI 3i Composites Technology Center, which serves as the research and development division of IDI, where the company generates and proves new ideas, approaches and materials to address the engineering and performance challenges of its customers. This division of IDI Composites International has helped develop Fortium high glass fiber composites, with 40-65% discontinuous glass fiber, and Ultrium carbon fiber composites. Booth X4.

Custom composite design, development

Rock West Composites (West Jordan, UT, US; San Diego, CA, US) is emphasizing its focus on design, development and manufacture of composite products, components and assemblies for custom applications and online sales. Stock manufactured offerings include tubes, plates, raw materials and related accessories. Custom services include full design, engineering, tooling and production. The company's manufacturing capabilities include resin infusion, bladder molding, roll wrapping, filament winding, press cure, closed molding and CNC machining. Rock West Composites serves market segments including aerospace, defense, medical, general industrial and automotive racing. Booth CC27.

CompositesWorld.com 19

Versatile, customizable filament winding systems

Engineering Technology Corp. (Entec, Salt Lake City, UT, US) is featuring its new line of standard filament winding systems, ranging from small tabletop models to premium production machines. The smallest winder, SS, is a low-cost machine designed for use in laboratories, universities and light production facilities. Mid-range winders, SM, feature sturdy, modular construction for full-scale production and support a range of options including additional axes and spindles. The largest winder, SL, is designed for heavy industry and aerospace and supports mandrels up to 2m diameter and 15m long. Rounding out the catalog, the fastest winder, CXG, is a multi-spindle machine specifically geared toward pressure vessels and the high-output demands of automotive manufacturers. Entec also is emphasizing its custom equipment and process solutions. These systems range from filament winders to tape wrappers and fiber placement machines. Entec is a certified FANUC integrator and develops robotic solutions and process integration that support increased process flow and quality control standards in the industry. Booth F74.

Preforms, 3D woven joints and thermal protection systems

Bally Ribbon Mills (Bally, PA, US) is featuring its line of specialty fabrics and preforms, including 3D woven joints, thermal protection systems (TPS) and other 3D structures. Bally Ribbon Mills uses 3D continuous weaving to create new joint structures and improve existing joints. 3D woven joints are available in "Pi," double "T," "H," and other complex net shapes. Bally Ribbon Mills says that because of the nature of the 3D weave, strength and support is translated in all three dimensions, thus enabling the join to reinforce the strength along the load paths of the substructures being joined together. These 3D woven shapes

for joining can be tailored to suit the architecture of the structure itself, as well as the sub-components being joined. Bally Ribbon Mills' ability to vary yarn types, density, thickness and width, as well as resin type, allows the company to create fully customizable TPS to fit specific mission or application needs. Notable applications include heatshields and aircraft engine parts. Booth S49.

Ultra-low density syntactic foam for core splicing

Magnolia Advanced Materials (Atlanta, GA, US) is exhibiting Magnolia 7035, a new, ultra-low density syntactic foam for core splice applications. Magnolia 7035 is a two-part epoxy paste that can be applied between the honeycomb sheets in the amount needed to bridge the gap. Magnolia 7035 cures at room temperature and can then be processed through a typical cure cycle for the face sheets. The pot life of the mixed resin is 30 minutes, and it develops handling strength in

less than 2 hours. The cured density of Magnolia 7035 is comparable to foaming adhesives, but offers favorable mechanical properties up to 250°F. Because it is a syntactic, it is a closed cell foam and thus will give the adhesive better environmental resistance than the open cell foaming type. Magnolia notes that typically, splicing of honeycomb sandwich panels requires the use of foaming adhesives, which expand during a heat cure to bond the honeycomb sheets. This process can require cutting strips of core slice sheets to size and then placing the strips between the sheets of honeycomb. During cure, the foam expands to fill the gap and bond the adjacent sheets together. If the cut edge is irregular, then the space may be too large in some areas for the foam to fill and the resulting gaps will compromise the properties of the sandwich panel. Magnolia contends that Magnolia 7035 eliminates these problems while producing a lighter, stronger and more environmentally stable panel. Booth BBI3.

Range of industrial ovens

LEWCO (Sandusky, OH, US) is exhibiting its line of industrial ovens, including a full range of batch ovens, conveyor ovens, drum ovens, tote ovens,



hot boxes, drum heating tunnels, large field-assembled ovens and high-temperature furnaces. The company also emphasizes its capability to engineer and manufacture custom equipment made to customer specifications. Booth H62.

Fly-away carbon fiber composites for aerospace

Janicki Industries (Sedro-Woolley, WA, US) is emphasizing its ability to

manufacture carbon fiber fly-away parts, tooling and prototypes for aerospace applications. Its JBXA prepreg cloth is offered in multiple configurations to match program needs. The cloth is pliable and designed to form complex shapes such as airfoils, fairings and control surfaces. It is



durable, cures in an autoclave at 360°F, retains vacuum integrity after more than 100 cycles and enables long out times to accommodate large laminates. Booth T48.

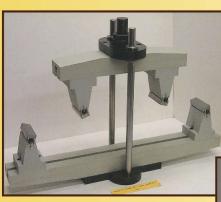
20

wyoming /Test /Fixtures

Celebrating
30 Years
of Excellence
1988-2018

- Over 40 types of fixtures in stock, ready to be shipped.
- Expert consultation with Dr. Adams
- Email or call today to discuss your fixture and custom design needs.

FLEXURE FIXTURES FOR EVERY SPECIMEN SIZE



Long Beam Flexure Fixture w/Alignment Rods and Bearings ASTM C 393, D 7249



Three and Four Point Flexure ASTM D 790, D 6272, D 7264



Miniature Flexure Fixture



Three and Four Point Short Beam Fixture ASTM D 790, D 6272, D 7264, D 2344



Reversed Cycle Flexural Fatigue

We provide quotes for a variety of grips, fixtures, and jigs. We carry over 40 types of fixtures in stock, available for immediate delivery. Email or call us today. We look forward to hearing from you.

Dr. Donald F. Adams

President
50 years of
Composite Testing Experience

2960 E. Millcreek Canyon Road Salt Lake City, UT 84109 Phone (801) 484.5055 Fax (801) 484.6008

email: wtf@wyomingtestfixtures.com www.wyomingtestfixtures.com

Curing agents, reactive diluents, tougheners, bio-based resins

Dixie Chemical (Pasadena, TX, US) is emphasizing its line of anhydride curing agents, reactive diluents, tougheners, resins and bio-based raw materials. Dixie's line includes modified anhydrides, which combine the performance benefits of specialty additives such as accelerators and mold release agents. Dixie also offers pre-catalyzed anhydride technology, leading to novel anhydride curing agents such as ECA 619 and NMA 419 for epoxy composites. These curatives allow for epoxy formulations with low viscosities, long pot lives, fast cures and high glass transition temperatures (Tg), suitable for high-speed pultrusion processes. Dixie also offers low-viscosity epoxy-anhydride formulations for infusion processes such as resin transfer molding (RTM) and high-pressure RIM. These systems cure at relatively low temperatures, opening up applications like damage-tolerant panels, cured-in-place pipe (CIPP) and electrical castings. Booth U19.

Three-press hydraulic system for molding medical parts

French Oil Mill Machinery Co. (Piqua, OH, US) and **TMP**, A Division of French, are featuring a self-contained, three-press system with one central press controller for compression molding of composite medical parts. Each compression press is designed with three daylights, totaling nine pressing surfaces for increased production rates. Each press is capable of 10 tons pressing capacity. The 6-inch square solid-steel plate pressing surfaces are designed with one heat-and-cool zone per



platen and independent setpoints on each lower and upper platen, for energy efficiency and consistent temperatures throughout the molding process. Each pressing surface is equipped with a programmable fan to accelerate temperature reduction on the mold during the cooling cycle. The press controller consists of a NEMA-type enclosure and is mounted on the side of the press system. The new generation PLC microprocessor system features a 10.5-inch color screen interface. The press controller shows a digital readout of press force for sampling, concurrent with sampling of temperature. Press force is recorded in the system, as well as time and temperature history, which can be used to confirm process repeatability. Booth N29.

Thermocouple assemblies for aerospace applications

TE Wire & Cable is showcasing its thermocouple assemblies designed for demanding high-temperature aerospace autoclave applications. The company's AccuClave-series products are said to provide labor savings, ease of installation/replacement, simple TRAC traceability and reduced non-conformances. The AccuClave autoclave thermocouple assemblies deliver high-accuracy temperature measurement and ensure that aerospace composites materials are properly cured during processing. They are available in temperatures ranging to 300°C/572°F, and are leak-proof and easily replaced after one or more uses.

TE Wire & Cable is also showcasing several of its other products. Its AccuFlex assemblies are low-profile flat thermocouple cable assemblies that come with TRAC traceability. TE Wire & Cable also has partnered with Plataine to develop its Ilot Smart AccuClave thermocouples for use in lead/lag, load and tool thermocouples, out-of-autoclave temperature monitoring, oven curing, hot bonder thermocouples and autoclave processing. AccuClave-X autoclave thermocouple cable extensions bridge the long runs between thermocouples and instrumentation or jack panels. They are reusable, remaining in place in the autoclave, and are available in lengths of 10, 20 and 30 ft. AccuConnect assemblies are multi-circuit thermocouple extension cable harnesses that can be used to improve cable connectivity in autoclave applications. AccuConnect can be supplied as six, 12 or 24 cables terminated with a multi-pin connector on one end with free-floating, independent male or female connections at the opposite end. They are said to reduce autoclave setup time by up to 90% and are reusable. SkinTemp Flat Junction tool thermocouples have fiberglass construction rated for continuous use ranging to 510°C/950°F. They are used for a parallel fit on tools, and come in type J, K, T, N or E thermocouple. The Bayonet Junction with Twist & Lock Adapter has fiberglass construction rated for continuous use ranging to 510°C/950°F. It is used for constant contact on tools, and comes in type J, K, T or E thermocouple. SkinTemp and the Bayonet Junction are also available in FEP, PFA and polyimide. Booth K31.

Prepreg system for thermoplastic composites

C. A. Litzler Co. Inc. (Cleveland, OH, US) is debuting its improved standard thermoplastic prepreg machines, available for water-based and solvent-based resins in various widths and fibers, for use with multiple resins systems. The prepregger features stainless steel, recirculating slurry dip tanks; mixing and distribution manifolds; submerged rollers to encourage wetting; water/solvent removal and resin pre-heating; infrared heating and a heated die. Litzler is also emphasizing in its booth the company's dryer technology, compaction rolls, tow-spreading capability and expertise in controls design and automation. Booth AA21.

Engineering Technology Corp

Toray Group



GLOBAL EXPERT FILAMENT WINDING & COMPOSITE SOLUTIONS

MORE THAN MACHINES



www.entec.com I +1 (801) 486-8721 I sales@entec.com









Surface finishing, high-pressure metering systems

Hennecke Inc. (Lawrence, PA, USA) is featuring developments in polyurethane composite fabrication technology, including products made with its COLOURLINE surface finishing and STREAMLINE highpressure metering machine systems. Visitors to the Hennecke booth also can learn about the Rim Coating Technology Center (RCTC), the first demonstration, development, validation and pilot production facility for RIM coating technology in North America. Co-founded in Livonia, MI, US, by Hennecke, Votteler and SA Engineering as a Ruhl Strategic Partners initiative, the RCTC helps OEMs and tier suppliers develop and test coating technologies and commercialize direct-frommold Class A parts.

Hennecke's COLOURLINE system is installed at the RCTC, where manufacturers can observe product quality and performance improvement potential by applying advanced polyurethane RIM coating chemistry directly in an injection mold. The COLOURLINE, says Hennecke, enables fast and easy color changes for high-quality, scratch-resistant surface finishing of parts. The COLOURLINE is installed as a stationary isocyanate unit on an injection molding machine. Working with the COLOURLINE system is the MULTI-CONNECT color module, which has its own heater and MN 8 MC mixhead and is designed as a compact, mobile station that blends and tempers the different color systems. The MULTI-CONNECT parking station can provide up to seven colors simultaneously, with each color circulating in its own system so that colors do not co-mingle during color changes.

Hennecke's STREAMLINE high-pressure metering systems can be equipped with everything necessary to produce fiber composite components by means of the high-pressure resin transfer molding (HP-RTM) process. The three-component STREAMLINE metering machine can process all current matrix systems for composite components, including polyurethane, epoxy or reactive polyamide 6 raw materials. Booth T21.

Closed-loop, modular tow-tension control units

the first prototype units of its closed-loop, modular, individual tow-tension control units, sponsored by a National Science Foundation SBIR Phase II Grant. Montalvo is showcasing how this new technology integrates within existing processes

to add a new precise,



continuous, automated tension control zone, said to deliver higher quality and productivity to composites manufacturing processes that use individual tows of material. In addition, the company's Modular Tensioning Cartridge (MTC) is said to advance the manufacturing capabilities of producers and users of composite materials. Montalvo is also highlighting its tension controllers, load cells, sensors, amplifiers, brakes, clutches and other tension control equipment used in prepreg, pultrusion, filament winding and converting composite applications. These products are said to reduce reliance on operators and manual control while improving productivity. The company's MTC technology and tension control components will be on display in a demo simulation from creel rack to rewind, to show visitors how tension control integrates throughout an entire process. Booth BB19.

Epoxy resin systems for wind, oil and gas, pressure vessels and more

Epoxy manufacturer Olin Corp. (Clayton, MO, US) is unveiling several new technologies for composite applications, which will be shown in finished products on display in Olin's booth (S13). Olin's latest products are available as well, including LITESTONE systems for composites and Wind Energy Systems from AIRSTONE. Finished products in the booth include:

- · Composite pressure vessel: Epoxy systems designed to help meet the increasing demands for lightweight composite vessels used as alternative energy storage systems for virtual pipeline and transportation applications
- Frac plug: Glass fiber-reinforced composite frac plugs for demanding fracking applications
- · Composite rigid pipe: High-temperature and corrosion-resistant industrial pipes
- Composite leaf spring: Lightweight, fatigue-resistant composites for automotive suspension
- Composite rebar: Corrosion-resistant, lightweight, long service life fiber-reinforced composite rebar for demanding infrastructure applications »

THE COMPOSITES PEOPLE.

Experience is everything.



Major manufacturers choose Kaman composites for everything from winglets and doors to engine structures —and with good reason.

Kaman's commercial and military customers know they can count on us for top-quality, flight-worthy structures ranging from monolithic to sandwich parts, delivered on time and within budget.

Kaman Composites U.K. David Owen

David.Owen@kaman.com +44 (0) 755.336.0171

Kaman Composites U.S. John Unghire

John.Unghire@kaman.com +1 860.243.7130

Visit us at CAMX 2018, Booth Y60

October 15–18, Kay Bailey Hutchinson Convention Center Dallas, Texas USA

KAMAN

Aerosystems

Kaman Aerosystems is a division of Kaman Aerospace Group.

Kaman Composites U.S.-Vermont Bill Berg

Bill.Berg@kaman.com +1 802.440.7208

Bespoke automated composites manufacturing equipment

Accudyne Systems (Newark, DE, US) is featuring its line of of customized automation equipment for producing intermediary materials,



preforms and finished parts.
Equipment developed by
Accudyne includes automated
fiber placement machines, flat
charge laminators, stringer
formers, cross-ply laminators,
de-bulking systems, noodle
formers, pick-and-place
laminators, kitting machines,

bladder wrappers and robotic tool management. The company's equipment supports production activities for the Boeing 787, Airbus A350, Gulfstream G600, the V-22 *Osprey* and other commercial and military aircraft. Booth Z21.

Composites testing solutions for extreme temperatures

Zwick USA (Kennesaw, GA, US) is displaying a variety of tooling, grips and fixtures designed to accommodate testing regimes. Products include interlaminar shear strength fixtures, load bearing test tools, hydraulic composite compression fixtures, 3- and 4- point flexure test



kits for fiber composite materials and compression test kits for end loading. The company's AllroundLine system is said to to perform more than 20 types of composites tests in compliance with more than 100 test standards. The TestXpert III test

software supports a range of applications from shear loading of composite sandwich specimens to open-hole compression testing in accordance with

ASTM, ISO and DIN standards, as well as company-specific standards. The MakroXtens extensometer can be used up to specimen break, even with high loads and brittle specimen material. With an integrated safety mechanism and rotatable knife edges, the operator and system are protected from specimen breakage. In addition, the company's newly designed temperature chambers are fully integrated in the testing systems and can test from -70°C to +250°C. They are compatible with ZwickRoell extension measurement systems, ensuring reliable test results for optical and contact measurements. The chamber's modular concept means the test setup can be adapted to suit the operator's needs. ZwickRoell industry experts will be on hand at Booth R55 to demonstrate a 10-kN AllroundLine universal testing machine featuring body-over-wedge grips and makroXtens extensometer.

High-temperature prepregs and adhesive systems

High-temperature materials specialists **Renegade Materials Corp.** and **Maverick Corp.** (both in Miamisburg, OH, US) are featuring their prepregs and adhesives, powered by Maverick-developed, non-MDA polyimide resins. Renegade Materials' exclusive 700°F RM-1100 polyimide prepreg is qualified or in qualification at multiple international aerospace OEMs. RM-1100 and Renegade Materials' exclusive 600°F MVK-14 FreeForm prepregs are approved for export and offer non-MDA options to replace PMR-15 as well as titanium in primary structure.

Maverick Corp. is featuring its family of high-temperature polyimide coatings and RTM resins, including MVK-2066, MVK-10 and RTM-1100. Renegade Materials is promoting its BMI product line including prepreg systems (RM-3002 and RM-3004), infusion resins (RM-3000 and RM-3010) and adhesives (RM-3011, RM-3006 and RM-3007). Renegade Materials' RM-3004, says the company, is the most mature out-of-autoclave (OOA)-processable BMI prepreg system in the industry, with applications in both aerospace structures and tooling. Renegade Materials has completed several key commercial aerospace qualifications of these BMI products and is now in high-rate production supporting these programs.

Renegade Materials also is featuring its low-dielectric prepreg system, RM-2014-LDk-TK. This modified epoxy system is said to offer cyanate ester-like dielectric properties at a much lower cost, and it processes in or out of autoclave. Booth Y20.



Composites design, manufacturing services

Matrix Composites Inc. (Rockledge, FL, US), a designer and manufacturer of a range of high-performance composite components and assemblies, is emphasizing its design, development, tooling, fabrication, testing and integration services. Matrix features precision resin transfer molding (RTM) and conventional composites. Other processes offered include hot isostatic resin pressure molding (HiRPM), compression molding, vacuum-assisted resin transfer molding (VARTM), autoclave curing, oven curing and trapped rubber and bladder molding. Notable application types include fixed and rotating engine components, integrated engine structures, engine nacelles, waste tanks, aircraft interior components, seat components, skins, heat and A/C ducts, wind swept surfaces, spars, radomes, antennas, fuselages and more. Booth J101.

Complete Composite Solutions

Fives Cincinnati and Fives Lund

Cincinnati Small Flat Tape Layer



Cincinnati VIPER 6000



Lund Slalom



Cincinnati GEMINI ATL/FPS



"With over 150 installations across the globe, Fives has more tape layers & fiber placement systems in operation than all other suppliers combined"

From nose to tail, complete composites aerospace solutions:

- Lamination, multiple ATL and AFP processes and systems
- Forming
- Ultrasonic cutting
- Co-bonding
- NDI
- Drill, mill and trim
- Automated assembly

Fives Cincinnati

2200 Litton Lane, Hebron, KY 41048 859-534-4600 — fivesmsi-sales@fivesgroup.com



Adhesives, resins, gelcoats and matched tooling systems

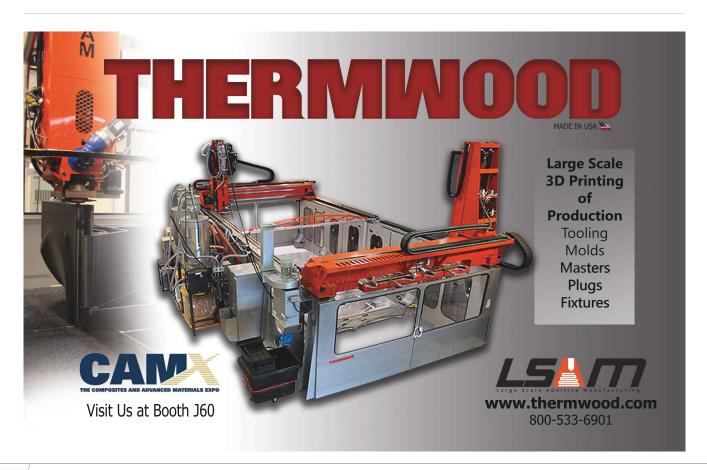
Scott Bader North America (Stow, OH, US) is featuring its lineup of adhesives, resins, gelcoats and matched tooling systems. A particular focus at CAMX is on Scott Bader's polyester, vinyl ester and hybrid bonding pastes under the new Crestafix brand name. Scott Bader bonding pastes are used in a range of applications and markets offering customers a choice of densities, gel times, color change, low shrinkage and ease of application.

A new Crestafix sampling kit has been developed to offer customers the opportunity to sample and compare their chosen Crestafix options. The Crestapol range of high-performance urethane acrylate resins is also a key product focus, with particular emphasis on the fire-retardant (FR) properties of filled Crestapol resins and Crystic FR gelcoats and intumescent topcoats. Crestapol resins can be processed by open molding, infusion, RTM and pultrusion, even when heavily ATH filled (up to 200 phr). Booth Q47.



Versatile closed cell foam

Elliott Co. of Indianapolis (Indianapolis, IN, US) is featuring its ELFOAM rigid unfaced polyisocyanurate (urethane) closed cell foam core. ELFOAM products are available in 2-, 3-, 4- and 6-lb/ft³ densities supplied as blocks, sheets and custom shapes. With a temperature range from -297°F to +300°F and compatibility with polyester, vinyl ester and epoxy resins, the foam can be used for a variety of applications. It is compatible with an array of processes including hand layup, sprayup, vacuum infusion, resin transfer molding, lamination, pultrusion and filament winding. In terms of physical characteristics, it is said to offer high strength-to-weight ratios, chemical resistance, thermal insulation, and Class 1 fire performance, as well as low water permeability. It also can be easily machined, perforated and sliced. Booth U51.



PEKK-based thermoplastics for additive manufacturing

Hexcel (Stamford, CT, US) is featuring one of it newest technologies, HexAM additive manufacturing technology, which combines high-performance PEKK thermoplastics with carbon fiber to produce flight-ready 3D-printed HexPEKK parts. Hexcel acquired this technology from Oxford Performance Materials in December 2017. HexPEKK structures offer weight, cost and time-to-market reductions, replacing traditional cast or machined metallic parts in highly demanding aerospace, satellite and defense applications.

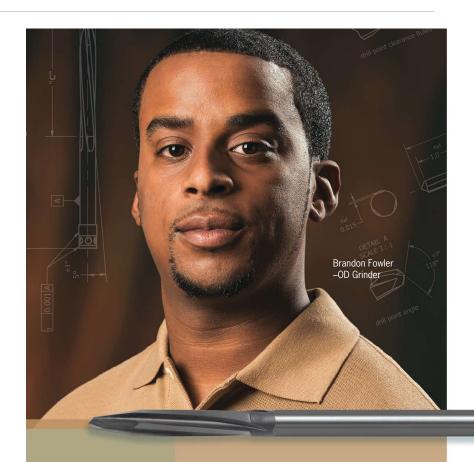


Hexcel also is presenting its HexShield thermal management system, which provides high-temperature resistance in aircraft engine nacelles. HexShield works by integrating a thermally resistant material into honeycomb cells, providing a core product with heat-shielding capabilities that allow for the potential re-use of material after a fire event.

Also in Hexcel's booth is Acousti-Cap broadband noise-reducing honeycomb, designed to improve acoustic absorption in aircraft engine nacelles. The acoustic treatment can be positioned at a consistent depth and resistance within the core, or can be placed in a pattern of varying depths and/ or resistances, offering an acoustic liner that is tuned to the engine operating conditions. Another Hexcel product at the show is the line of unsized HexTow carbon fibers for use with thermoplastic matrices; included is its newest high-modulus fiber, HexTow HM50, for commercial and defense aircraft and engines. Hexcel is promoting its latest PrimeTex woven carbon fabrics that decrease areal weight while providing a smooth, closed weave and uniform cosmetic appearance, and its HiMax multiaxial reinforcements. Booth Y13.

Composites materials distribution services

Composites material distributor **Pacific Coast Composites** (PCC, Puyallup, WA, US) is emphasizing its new agreement to distribute products from **Solvay Composite Materials** (Alpharetta, GA, US). PCC is also prepared to discuss its expanded product line that now includes more than 6,000 products, like consumables, tooling materials and accessories. On display are film adhesives, prepreg materials, temperature monitors, honeycomb core and other products. Booth H70.



WORKS FASTER, LASTS LONGER.



Drilling out through a face-down OML (outer mold layer) is tricky business.

That's why the world's leading fighter jet manufacturer looked to AMAMCO for the right composite drill.

This diamond coated carbide drill works 12.5 times faster than PCD and lasts 4.36 times longer.

800.833.2239 www.amamcotool.com

CompositesWorld.com 29

Multiaxial and woven reinforcements, vacuum bagging supplies

METYX Group (Istanbul, Turkey), a manufacturer of high-performance technical textiles including multiaxial reinforcements, carbon fiber reinforcements, RTM reinforcements, woven reinforcements and vacuum bagging products, is emphasizing its new manufacturing capacity in Ranlo, NC, US. The facility, in which METYX invested US\$3.5 million, includes 30 acres of land and a 12,000m² plant. The US operations in North Carolina, expected to employ up to 200 people in near future, are initially focused on setting up technical textiles production lines for manufacturing a range of glass and carbon fiber fabrics, along with sales, customer service and warehousing facilities to serve the North American composites market. As a next phase, in line with customer needs, fabric, core and vacuum consumable kit cutting capabilities will be added.

METYX is primarily looking to establish business with US and Canadian OEMs and Tier 1 converters in the wind energy generation, marine, road and rail transportation and industrial sectors. Booth K37.



Electric, gas, indirect gas composite curing batch ovens

Wisconsin Oven Corp. (East Troy, WI, US) is featuring its electrically heated, gas-fired and indirect gas-fired composites curing batch ovens. Options commonly used for composites curing ovens include data acquisition instruments, vacuum piping, pumps and transducers. The ovens are said to provide:

- Quick heating rates and recovery times: Each oven features

 high-pressure recirculation blower, which includes fully
 enclosed and pressurized supply ducts. The equipment is
 designed for combination airflow arrangement, which ensures
 uniform heat distribution throughout the work chamber, even
 with varying loads.
- Consistent temperature certification: Composites curing ovens are typically guaranteed and certified for ±10° at 350°F temperature uniformity. Tighter tolerances and certification at other temperatures are available. Equipment is tested prior to shipment and must pass an extensive quality inspection prior to shipment.
- Energy efficiency: The composite curing batch ovens are also available with an optional E-Pack Oven upgrade that includes thicker wall panels and higher efficiency motors.
 Booth AA39.

Uniform, indirect inductive heating for composite repair

HEATCON Composite Systems (Seattle, WA, US) is introducing HCS9400-02 Smart Susceptor technology, which uses indirect inductive heating to help provide thermal uniformity in composite repair operations. The common concepts related to zones of heat and control required to



achieve thermal uniformity do not apply for this unit. Instead, the Smart Susceptor produces power in the 100-kHz frequency range to operate induction-heating susceptor blankets. The custom-designed alloys of the susceptor wires have a Curie point (where they lose magnetic induction properties) at the process cure temperature. This results in a "self-regulating" effect near process temperature — colder sections of wire continue to produce heat while hotter sections stop producing heat, thus improving temperature uniformity. HEATCON says Smart Susceptor technology enables the blanket to perform an active role in heat distribution, effectively reducing power (heat) to the areas that have reached the desired temperature, while continuing to apply heat to the cooler areas. Like the company's legacy hot bonders, the HCS9400-02 Smart Susceptor is said to be user friendly, using hardware and software to provide the composite repair technician with complete control of the hot bond cure process. Booth BB32.



Filament winding, prepeg technology

Roth Composite Machinery (Steffenberg, Germany) is emphasizing its filament winding and prepreg abilities, with specific focus on its ROTHAWIN technology, robot winding and its Type 1-ECO machine. ROTHAWIN technology is said to accelerate winding processes by five to 10 times, making it suitable for series and mass production of pressure vessels in the automotive industry. The company also presents its new machine concepts for robotic filament winding processes, designed for research and development and for small-series production. The Type 1-ECO machine was developed as a standardized version of the gantry-type filament winding machine, an entry for the company into the serial production of filament winding machines. The machine is equipped with essential basic functions and is said to offer robustness, durability and precision. It has a modular concept of up to four spindles, up to four winding axes and two length variants (one ranging to 4,000 mm and the other ranging to 10,000 mm). Booth BB50.

30

Room-temperature cure adhesives for aerospace, automotive

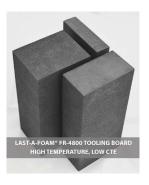
L&L Products (Romeo, MI, US) is presenting its room-temperature cure adhesives for applications that require fire and smoke and toxicity performance. Two new adhesives include L-9150 and L-9115. L-9150 is a two-component adhesive with a 1:1 mix ratio, which cures at room temperature or can be accelerated with heat. It provides high-performance bonding (work life 35-50 minutes). L-9115 is a two-component, toughened adhesive

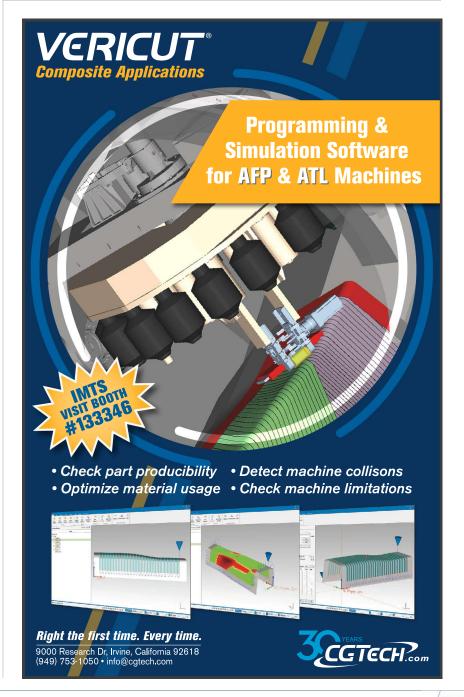


that cures at room temperature and provides high-performance bonding (work life 10-20 minutes). Both adhesives are designed for aerospace interior applications and meet FAA fire regulations (vertical burn, smoke density and toxicity). Also in the L&L Products booth is the company's newest technology, Continuous Composite Systems (CCS), which combines highly engineered sealants and adhesives with a fiber-reinforced composite carrier in a two-dimensional profile designed to provide strength, stiffness and rigidity in a lightweight structure. Also new from L&L Products is a structural adhesive foam, L-5920, an epoxy-based structural foam with higher strain to failure than traditional structural foams. It is commonly paired with a reinforcing material such as nylon and then designed to create an engineered structural insert. The heat-activated foaming structural material is intended for crash applications with improved strain to failure and modulus (strain energy). L-5920 has a higher vertical rise at the same volumetric expansion than its Generation 3 predecessor, L-5520, meaning it is capable of spanning larger gaps and achieving adhesion more quickly during heat exposure and thereby producing more durable bonding. Booth N21.

High-temperature, low-CTE tooling board

General Plastics (Tacoma, WA, US) is featuring its new high-temperature, low-CTE LAST-A-FOAM FR-4800 tooling board. FR-4800 withstands peak temperatures up to 480°F/249°C and continuous use up to 400°F/204°C. It reportedly will not warp or twist and remains dimensionally predictable, even at elevated temperatures. With a CTE that is similar to aluminum and a density that is only a third of it, the FR-4800 is said to be a strong alternative to metallic tooling. Booth AA32.





CompositesWorld.com / 31

Portable hot bonders, vacuum tables enable mobility

BriskHeat (Columbus, OH, US), a provider of flexible heating, insulating and temperature control solutions, is emphasizing its news that AeroNed BV is now the authorized location for BriskHeat's ACR hot bonder calibrations and repair in Europe. Located in The Netherlands, AeroNed will perform these services for BriskHeat's ACR 3 Hot Bonders and ACR MiniPRO Hot Bonders. BriskHeat ACR hot bonders control

the heat and vacuum for on-the-spot composite and



BriskHeat also manufactures a range of custom heating blankets, radome heaters and vacuum curing/debulking tables for the repair of composite materials and other heating applications. Booth E65.



Bio-based sheet molding compounds

A. Schulman (Fairlawn, OH, US) is featuring its two newest sheet molding compounds (SMCs), Premi-Glas 7001 and Premi-Glas 3501. Premi-Glas 7001 is a bio-based solution that incorporates renewable feedstocks obtained from vegetable oil. It provides flame-retardant capabilities and delivers a Class A surface profile, making it well-suited for critical appearance parts, including body panels, hoods and access doors on large agricultural equipment.

A. Schulman's Premi-Glas 3501 is designed for applications where surface profile is not as critical, such as electrical enclosures or HVAC components. In addition to offering a bio-based resin system, Premi-Glas 3501 also can be formulated with recycled content while maintaining favorable flame-retardant properties and molded in color. A. Schulman officials stress that sustainability is important to the company as it looks for opportunities to support the circular economy and reduce its environmental impact, while meeting customer and industry needs. Booth H73.



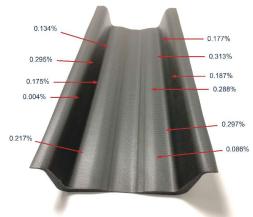
Thermoplastic, thermoset resin systems for high-performance applications

TenCate Advanced Composites (Morgan Hill, CA, US), a Toray Group company, is highlighting in Booth V15 new thermoplastic and thermoset composite solutions, as well as its new Product Selector app, which provides users with full access to literature along with product comparison tools, and cured ply calculators. Among the technologies of emphasis are:

- Novel use of recycled thermoplastics: TenCate is highlighting the
 development of a thermoplastic chopped fiber flow layer, which allows
 almost 100% yields in aerospace-grade
 thermoplastic laminate applications. This
 process demonstrates the use of trim and
 yield loss to produce local reinforcements and
- TenCate TC380 OOA/VBO Epoxy: TC380 offers high compression-after-impact strengths while maintaining good open hole compression strength. A 90-plus ply part is on display, demonstrating less than 0.1% voids in VBO processing.

discrete parts.

- Aniform software: A demonstration part and fabrication video highlight the use of this novel simulation software, which characterizes and optimizes thermoplastic part molding conditions, minimizing manufacturing trials and shortens development times.
- TenCate TC1320 PEKK: TenCate's thermoplastic unidirectional tapes are part of Airbus's TAPAS program thermoplastic upper spar demonstrator. A video demonstrates the manufacturing flexibility of the company's thermoplastic unitapes in large-part automated tape laying (ATL) fabrication.
- Dr. Hans Luinge, TenCate's thermoplastic R&D development manager, is presenting a technical paper on the benefits of a hybrid thermoset/thermoplastic composite solution for optimizing the material performance and minimizing cost.
- HP Spectre laptop case: This lightweight, ultrathin thermoplastic case minimizes heat transfer through the bottom of the laptop, while providing an impact-resistant, UL-94compliant solution.
- High-Performance footwear laminates:
 TenCate's thermoplastic laminates, used
 by several athletic footwear brands, are on
 display. These materials are designed for
 high-volume production solutions to support
 the latest generation of footwear and medical orthotics.





CompositesWorld.com / 33

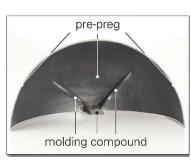


Mold and tool cleaning with blasted dry ice

Dry ice cleaning specialist Cold Jet (Loveland, OH, US) is conducting demonstration of mold and tool cleaning using the company's i³ MicroClean system. Dry ice blasting is a non-abrasive cleaning method that provides a composite tool cleaning solution that is fast, delicate and does not use chemicals or solvents. Dry ice cleaning uses recycled CO₂ in the form of solid dry ice pellets that are accelerated by compressed air through high-velocity nozzles onto the surface being cleaned. Through the combination of the kinetic and thermal effects, the bond between the contaminant and the surface is broken, thus cleaning the substrate. The dry ice pellets sublimate (return to their gaseous state) upon contact and expand 800 times to flush the contaminant from the surface. ColdJet says the i³ MicroClean enables the cleaning of intricate cavities that other methods cannot reach and extends the life of equipment by eliminating the need for chemicals, wire brushes and abrasive pads. It also is said to allow for increased cycles between preventative maintenance, while reducing scrap. Tooling used for, but not limited to, compression molding, resin transfer molding, extrusion, prepregging and wet layup are all suitable applications for dry ice blast cleaning. Booth P60.

Prepreg for multimaterial compression molding

Norplex-Micarta (Postville, IA, US) is featuring its recently introduced EnableX, a continuous fiber prepreg that can be co-cured in a multimaterial molding system to produce near net shapes. EnableX materials



are specifically designed for compression molding and tested by Norplex-Micarta to ensure compatibility with the process. In addition, Norplex-Micarta's in-house laboratory and development capabilities allow for new concepts to be prototyped, or datasets to be developed to support

specific design criteria. EnableX has been verified on several epoxy and phenolic resin systems, with more in development. Reinforcement options include natural fibers such as cotton or paper, carbon fiber, glass fibers and fibers that significantly alter the behavior of the material such as PTFE or thermoplastics. Booth X4.

Composites manufacturing and repair training services

Abaris Training Resources Inc. (Reno, NV, US) is featuring its composites manufacturing and repair training services. Abaris recently relocated its Griffin, GA, US, operation to the Composite Prototyping Center's (CPC) 25,000-ft² facility on Long Island, NY, US, to enable expansion of the company's curriculum. At CAMX, Abaris' Lou Dorworth is presenting a pre-conference tutorial on Monday, Oct. 15, 1:00-4:00 p.m., titled "Enabling Technologies for Bonding and Joining Composites." He will



highlight various composite joining and bonding methods and techniques currently employed in the industry. Many Abaris Training partners and associates will also be located nearby on the exhibit show floor to answer questions about such products as repair equipment, vacuum bagging materials,

additive manufacturing, tooling, laser projection, resins, fibers, prepregs, thermoplastics and other associated material and process solutions. Booth R48.

Compact waterjet for range of composite materials

OMAX Corp. (Kent, WA, US) is highlighting its versatile ProtoMAX waterjet, which can cut through a range of materials including



fiberglass, phenolic, fiber laminate, carbon fiber and G10 composite. The machine's compact footprint and versatility is said to make it ideal for prototyping, educational applications or as a complement to a larger machine shop. The waterjet's pump and cutting table are on casters for easy relocation. It has a clamshell cover and submerges the work material underwater for safe, quiet cutting at approximately 76

db. The waterjet delivers 30,000-psi cutting power with a 5-hp pump. It cuts with no-heat-affected zone and no change to material properties. The waterjet plugs into a 240V AC dryer-style outlet and does not require hardwiring. ProtoMAX is controlled by OMAX's Intelli-MAX Proto software. Software comes pre-installed on an included laptop and is said to simplify the conversion of drawings to cutting paths. Booth K30.

Braided fabrics for thermoset and thermoplastic resin systems

A&P Technology (Cincinnati, OH, US) is exhibiting engineered braided fabrics designed to enable cost savings. Bimax, a $\pm 45^{\circ}$ off-the-roll fabric, is said to eliminate the need to cut 0°/90° woven fabric on the bias, saving time and money. QISO, a 0°/ $\pm 60^{\circ}$ fabric, is balanced in a single ply enabling easy lay-up and eliminating the need to orient plies. Benchmarked against comparable woven fabric laminates, QISO reportedly outperforms in tension, compression, open hole and impact events.

In addition to standard fabrics, A&P's range of braiding machinery allows for design

flexibility and the customization of hybrid fabrics to optimize part requirements, reduce waste and reduce manufacture costs. Custom fabrics include those with hybrid architectures (e.g., triaxial regions within a biaxial fabric), hybridized material systems and customized widths. A&P's braided fabrics are processed by



all major prepreg suppliers and are available in thermoplastic form as well. A&P braids narrow-slit thermoplastic tapes into preforms or wide fabrics, and A&P also provides wide fabrics for the production of thermoplastic billets or thermoplastic semipreg – fabrics that are post-treated and coated with thermoplastic resin film.

Engineered braided fabrics are also combined with bulk molding compound (BMC) or sheet molding compound (SMC) to provide structural reinforcement in high-load areas. The use of braid with SMC, says A&P, enables quick cycle production of highly structural parts. Liquid compression molding (LCM), another quick-cycle fabrication method, also takes advantage of the tailorability of braid. A&P provides multiaxial fabrics for LCM that offer superior performance and are designed to drape. Booth U3.





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.









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

Cutting and kitting technologies

Autometrix (Grass Valley, CA, US) is displaying its automated cutting tables and associated systems, including the Radium model, a static cutting table system, and the Catalyst model, a conveyorized cutting

system. Also featured is a demo of the company's Patternsmith software, which allows creation of patterns from scratch or from import via standard design files. Autometrix' CadShot Mobile tool allows users to digitize patterns, whether they are hand-drawn templates or unprocessed original pieces. CadShot

works with a smartphone or tablet's camera function. Finally, at the Autometrix booth, visitors can use a virtual reality system to visit the offices of Allied Cycle Works and watch the production of an Autometrix Bicycle using an Autometrix Radium cutting table. Booth 3221.

Composite molding presses

Wabash MPI (Wabash, IN, US) and Carver Inc. (Wabash, IN, US) are featuring their standard and custom presses to highlight their composite molding presses for manufacturing and laboratory applications. Wabash MPI also offers standard and custom hydraulic

and pneumatic presses for

compression molding, vacuum molding, ASTM testing, laboratory and R&D applications. Its transfer presses reportedly offer precise molding of electrical components, medical products and other applications. Carver Inc. offers two-column and four-column benchtop, manual and automatic hydraulic laboratory presses with clamping capacities of 12-48 tons. Carver presses are suitable for various materials research, as well as analytical chemistry, lab testing, laminating and other applications. Booth H69.



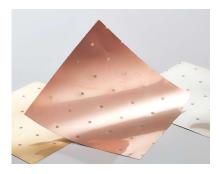
Cutting table with automated ply stacking

Eastman Machine Co. (Buffalo, NY, USA) is showing the Talon 25x cutting table, designed to automatically pull stacked material plies from the spreading table to a modular, bristle-block conveyor bed for reciprocating knife cutting of up to 1.18 inches/30 mm of compressed material goods. High-speed, precision cutting demonstrations of fiberglass, fiberglass insulation, aramid and other technical textiles are being featured. The Talon features a quick-change cutting knife and single-coated diamond sharpening disk to provide a robust cutting edge.

The Talon is optionally available with a cutting capacity of 3 inches/75 mm, several widths and a variety of vacuum blower configurations. The system also offers what is said to be easy access to the knife system and assembly parts, to help simplify daily maintenance procedures. Also in the Eastman booth is the company's Recipro-Cool Drive Assembly, an internal crank cooling system engineered to reduce heat and wear/tear to the horizontal crank mechanism that drives the knife up and down. Booth 3331.

Precision plating solutions

SAT Plating (Troy, MI, US) is emphasizing its focus on creating precision plating solutions for carbon fiber composites and high-performance PEEK and PEI materials. The company's suite of Adaptive Plating Technologies reportedly enables clients to expand their approach to product design, material selection and production methodologies. The company's technologies and processes can be applied to a range of



polymers and materials including plastics, films, fibers, membranes, fabrics, ceramics and glass. Hybrid and exotic materials can also be processed and plated, and include: glass fiber-reinforced PEEK, PEI and nylon; carbon fiber-reinforced PEEK, PEI and nylon; and metallic-powder materials mixed with polymers and injection molding. Industries serviced include aerospace, medical, cyber security, industrial applications and more. Typical plated component enhancements include improved wear resistance, EMI/ RF shielding, cosmetic enhancement, and improved strength and thermal performance. Booth M107.





Balsa coating system to reduce resin uptake

CoreLite (Miami, FL, US) is featuring its next-generation PC11 Pro coating system for its BALSASUD core series. The PC11 Pro coating system was engineered to significantly reduce resin uptake during the lamination process by sealing the pores in the end-grain balsa wood sheet more effectively than the standard PC11 coating system. CoreLite says balsa core resin uptake was compared between the standard PC11 formulation and the newly developed PC11 Pro formulation against non-coated balsa. A typical sheet of non-coated balsa wood core will absorb roughly 1900g/m² of resin during infusion. The standard PC11 formulation was able to reduce the resin

uptake by up to 46% to 1020g/m². The new PC11 Pro formulation is said to reduce resin uptake further, to 450g/m². This coating, says CoreLite, can be used in wind, marine, rail, automotive, aerospace, defense and industrial applications. It is compatible with hand lay-up, vacuum bagging and infusion. Booth BB10.

Boron, SCS silicon carbide monofilaments

Specialty Material Inc. (Lowell, MA, US) is showcasing its boron monofilament and prepreg, as well as its SCS silicon carbide monofilament (SiC). Boron monofilament is said to have high compression strength, with typical composite compression strength for boron/epoxy composites in the range of 400 ksi. In addition, it provides high composite tensile strength (220 ksi) and high tensile modulus (28 Msi). Other features of boron fiber are its positive coefficient of thermal expansion (CTE) for space applications, its lack of need for coupling agents in making strong and tough composites, and its absence of galvanic corrosion with aluminum. The company's SCS SiC fibers are said to increase the strength, stiffness and use temperature of titanium matrix composites and provide toughness to ceramic matrix composites. Booth DD33.

Natural rubber latex bladder fabrication for bladder molding

Piercan USA Inc. (San Marcos, CA, US) is featuring its natural rubber latex bladders used in bladder molding for composites fabrication. Bladder molding is the process of manufacturing a composite part using an inflatable natural rubber latex bladder inside a female mold to ensure compaction during the cure of the carbon fiber layup resulting in the finished hollow piece. Piercan manufactures the latex bladder by dipping a male mandrel, supplied by the customer, into its tanks of raw material, and then cure the dipped mold in its oven. Once cured, the formed bladder is then stripped from the mandrel itself. Piercan's bladders can be reused 10-15 times depending on the temperature of cure and complexity of the shape. The bladders can stretch up to 500% and handle up to 800 psi inside a closed cavity. Booth J51.

Thermoplastic and thermoset compression molding technology

Langzauner (Lambrechten, Austria) is exhibiting its Perfect line of hydraulic press technology for thermoplastic and thermoset material

processing, as well its automation of material and mold handling. Langzauner's presses are designed for use with sheet molding compound (SMC), glass mat thermoplastic (GMT), bulk molding compound (BMC), resin transfer molding (RTM), crush core



and thermoplastics like PPS, PEI, PEEK or similar. Press features include maintenance-free cylinder technology, servo/hydraulics with pressure accuracy of ±1%, optimized pump technology, active parallel control, platen heating up to 500°C, automation and robot integration, flexible software, data management and Industry 4.0 compatibility. Booth J23.

Metal-composite bonding technology

Structural Composites Inc. (Melbourne, FL, US) is emphasizing its being awarded the 2018 Defense Innovation Award for its metal hybrid composite technology. The annual TechConnect Defense Innovation Awards recognizes the top 15% of submitted Challenge technologies as ranked by the selection committee. Key to winning the award, and a focus of the company's CAMX exhibit, was Structural Composites' CoCure resins, coatings and adhesives, which form a tenacious bond to metals, allowing the creation of metal hybrid laminates using the same resin as used in the fiber composite layer. Hybrid structures can be created by stamping or forming the shape in thin-gauge metals (70% thinner than used by themselves), and then laminating the metal part with CoCure composite materials. This allows for fabrication of stiff structures at reduced weight, but at costs that can compete with traditional fabrications. The technology is already deployed by Wabash National in the semi-trailer market.

Structural Composites is also featuring the US Navy's 7m Advanced Combatant Craft (7ACC) for Increased Affordability, a rigged-hulled inflatable boat (RIB) the company helped develop, manufactured using its PRISMA composite preforming technology. The boat features innovations in diesel outboard technology that combine with design and material innovations to transform the craft from a single inboard engine platform into a highly capable dual outboard engine performance craft. Booth G62.

38

Composites R&D for infrastructure applications

The NSF Center for Integration of Composites into Infrastructure (CICI, Morgantown, WV, US) is emphasizing its advanced fiber-reinforced polymer (FRP) composites and techniques for rapid repair, upgrading, rehabilitation or replacement of highway, railway, waterway, bridge, building, pipeline and other structures. The center consists of West Virginia University as lead institution, North Carolina State University, University of Miami and the University of Texas at Arlington as partner university sites. The center also has two international sites, Nanjing Tech University of China and the Center for Engineering and Industrial Development of Mexico. The primary objective of the Center is to accelerate the adoption of polymer composites and innovative construction materials into infrastructure applications through collaborative research between member universities in collaboration with the composites and construction industries. Booth D46.

PPE safety hoods designed for composites fabrication

VitaFlex USA is featuring its Safety Ninja hoods, made from PPE and said to provide



effective primary head protection for workers in composite molding, fiberglass layup and spray coating environments. Made of latex-free elastic nonwovens, the hood securely covers the entire head, face and neck. The soft form-fit creates an

effective isolation layer next to the skin. Its dense, multilayer composite structure blocks micron-sized particles, glass fibers and paint or coating overspray. The ultra-fine intertexture gaps between fibers enable body heat and perspiration moisture to escape, keeping the head cool during extended wear. The hoods are said to improve safety, comfort and job efficiency for workers. Limited quantities of free samples are available to visitors. Booth N105.

Pultrusion system with servomotor pull control

Kent Automation (Kent, OH, US) is featuring its line of pultrusion systems that feature the ServoPul system. ServoPul offers completely non-hydraulic servomotor and drive technology to control pulling and clamping forces during pultrusion, and to register monitored feedback to the operating system. Kent notes that, with servomotors, challenges common with standard hydraulic systems are eliminated; further, pulling and clamping forces are said to be more precisely controlled using a servo/ball screw combination with zero backlash. Other features of Kent pultruders include touchscreen control, side or top die location, safety interlocks, flying cut-off saws and more. Booth U52.









815-987-6000 | www.ingersoll.com



Building our future...together!

Infrared emitters, pulsed heat technologies

Heraeus Noblelight America LLC (Buford, GA, US) is demonstrating new technologies from its Infrared Process group and it Arc & Flash group. The Infrared Process group is presenting Black.infrared emitters, printed metallic filaments located between high-purity guartz glass. The lower plate is made of special HBQ quartz glass; the top is protected by a layer of QRC (quartz reflective coating). The filaments can be adapted to customer requirements. The infrared radiation is emitted at the highly emissive HBQ side. The entire structure helps to direct infrared radiation homogeneously to the product to achieve a particularly efficient heat process for composites curing applications. Along with Black.infrared, the Infrared Process group is exhibiting Carbon Infrared Emitters and shortwave emitters. Carbon Infrared Emitters provide high heating efficiency and rapid cool down, providing response times comparable to shortwave lamps. The shortwave emitters are said to be particularly well-suited for processes that require guick start-up and shut-off. The Arc & Flash group is featuring its Humm3 technology for heating during automated fiber placement (AFP). It offers a pulsed light solution, designed to deliver uniform, highly controllable heat to the nip point area, over a range of temperatures. Humm3 controls the heat profile using three programmable pulse parameters (energy, duration and frequency). In testing with Hexcel's HiTape dry fiber product, Heraeus Noblelight says Humm3 achieved layup speeds of more than 1 m/s. Booth CC32.

Vacuum pumps for RTM, autoclaves

Republic Manufacturing (Dallas, TX, US) is exhibiting its line of vacuum pumps for composite manufacturing operations, including autoclaves, automation equipment, resin transfer molding and more. The Republic RX-Series oil-lubricated rotary vane pumps are a drop-in solution for vacuum needs. Air-cooled and direct-driven for continuous operation, they provide an airflow range up to 445 CFM and vacuum of 0.5 Torr. For a more energy efficient and low maintenance solution, Republic offers the RCV-Series rotary claw vacuum pumps, which reach a maximum continuous vacuum of 24 inches HgV. These pumps are dry-running, positive displacement pumps suited for oil-free applications. They use high-precision machined claws that rotate in synchronization without contact to create compression without wear. Republic also offers central systems in standard and custom configurations to provide a centralized source of vacuum. Booth CC23.

High-performance thermoplastic yarns and fabrics

Inman Mills (Inman, SC, US) is introducing its Texim thermoplastic yarns and fabrics, which feature a sheath of polymer fibers covering a reinforcing fiber core. Polymer fibers for the sheath may be from polypropylene, polyethylene, polyester, nylon, polycarbonate, polyetherimide, polyphenylene sulfide or almost any thermoplastic fiber that



can be extruded into a fine staple fiber. The ratio of sheath thermoplastic polymer fibers to the core reinforcing fibers can be adjusted, depending on consolidation and reinforcement requirements. Inman's differentiating technology combines the reinforcing fiber core and the thermoplastic polymer in one process at the yarn level, prior to the fabric being woven. Unlike a film or a co-woven, says Inman, the resulting product allows for improved consolidation as the polymer fibers surround the reinforcing fibers and reduce the possibility of voids in the final composite. Booth J49.

Automated ply handling system for cutting, kitting, layup

ARM Automation Inc. (Austin, TX, US) is featuring the Ply Picker, a fully automated solution for cutting table clearing, ply inspection, kitting and ply layup. The Ply-Picker system, says ARM Automation, addresses the need for picking of complex cut fabric shapes for part inspection, kitting and automatic layup of preform stacks, while addressing the challenges associated with cut-ply picking and handling, such as complex/varied shapes, uncut fibers and ply distortion. This patentpending solution identifies uncut fibers and stuck materials prior to lifting them from the nest. Ply shapes and surfaces reportedly are presented in an undistorted manner for high-resolution inspection and in-situ FOD detection. These plies can be placed into kits or directly laminated into preform stacks, with automated removal of backer material and post-layup inspection. The Ply-Picker system can be adapted to cover a range of shapes and sizes, including those smaller than a thumbnail to others as large as the cutting table itself. The robotic workcell solution derives pick information directly from ply shape data and dynamic nest location information to locate ply shapes and deliver them to kit locations. Lower volume operations may require a single robot stacking plies onto open kit tables at rates of only a few plies per minute. More intensive applications can use multiple pick heads simultaneously, tending one or more conveyorized tables and delivering pieces to automated kit carts or layup stations. Booth F34.

Resin transfer molding fabrication services

Fiber Dynamics Inc. (Wichita, KS, US) is featuring its design and fabrication services for the manufacture of simple to complex out-of-autoclave composites using the company's resin transfer molding (RTM) and lost core RTM processes. Fiber Dynamics is also prepared to discuss its one-shot integrated structure solutions, which is said to offer customers increased performance at a lower potential total cost to the customer. Fiber Dynamics is executing an expansion project that will double its facility size from 35,000 ft² to 70,000 ft² in 2019. Booth Y56. **>>**





Reusable vacuum bagging materials

Smartech (Charlotte, NC, US) is introducing Steinbach's reusable vacuum bagging materials. The materials are said to pair high elongation with tear resistance to make vacuum forming and infusion processes easier and more cost-efficient. Steinbach offers a variety of reusable silicone vacuum bag materials in sheet form or as a two-sided, sealed bag. Booth M53.



Aluminum metal-matrix composites

DWA Aluminum Composites USA Inc. (Chatsworth, CA, US) is exhibiting powder-metallurgy-based aluminum metal-matrix composites (Al MMCs), a family of advanced materials used for demanding aerostructural applications in civilian and defense platforms. DWA-USA converts blended aluminum and silicon carbide (SiC) ceramic powders into vacuum hot-pressed (VHP) billets, which are processed into a variety of shapes and forms using conventional extrusion, forging and rolling. VHP billets range up to 900 lb, so large-scale, semi-finished raw materials and finished parts can be produced to meet almost any customer requirement. The primary attributes of DWA-USA Al MMCs are their high isotropic strength- and stiffness-to-weight, fatigue resistance, durability and damage tolerance. The typical gain in yield strength compared to conventional 2000 and 6000 series aluminum alloys is 25-50%, depending on the level of SiC particle reinforcement. Al MMCs reportedly can match the stiffness of titanium



while maintaining the density of conventional aluminum. Estimated weight savings for stiffness-critical designs range from 20% to more than 50% compared to aluminum, titanium and steel. DWA-USA says Al MMCs offer a high level of "fit, form and function" in the manufacturing environment compared to other composite materials because normal metalworking and finishing practices are used with little or no modification. Machining of complex geometries with demanding dimensional tolerances are easily accomplished using diamond (PCD) tooling. Chemical milling is said to be superior to conventional aluminum given the ultra-fine microstructure of Al MMCs. The surface treatments commonly used for aluminum alloys can be applied to Al MMCs as well. The fatigue resistance of DWA-USA's 2009/SiC/15p Al MMC is twice that of AA2024 and AA7075. This has led to it being a material of choice for multiple critical rotating parts on helicopters, providing significant weight savings compared to previously deployed titanium components. Most recently, 6092/SiC/25p Al MMC has been introduced as lightweight bearing liners for helicopter gearboxes, replacing heavier steel parts. Booth Y51.

Mobile analysis of surface free energy

KRÜSS USA (Matthews, NC, US) is featuring its Mobile Surface Analyzer (MSA), designed to provide on-site quality control of pretreated or coated surfaces. It offers oneclick measurement of surface free energy based on contact angles in less than one second. The result enables determination of surface wettability by aqueous or organic liquids — for example, for coatings. The MSA doses two parallel drops - usually water (polar) and diiodomethane (non-polar) within milliseconds, with what is said to be high-volume precision and minimal kinetic energy. KRÜSS says that simultaneous dosing and analysis of two drops obviates the need to change the test liquid during the material testing, as is the case with conventional dosing units. The MSA is designed for mobile and non-destructive quality control and measures samples of any size, such as automobile bodies, and reportedly provides reliable values, even for vertical surfaces. Booth BB41.

Filament winding and pultrusion equipment and auxiliaries

Pultrex Ltd. (Manningtree, UK) is featuring its standard and bespoke filament winding, pultrusion and auxiliary equipment. Included are winding machinery from single to multiple spindles from the MODwind range for bespoke components. The Mini Winder, with maximum diameter of 500 mm, offers up to four axes of control with a maximum length of 4m. Labwinds, for universities and laboratory applications, offers 300 mm maximum diameter and maximum length of 2m. Pultrex also offers resin impregnation, tensioning systems, mandrel extractors, data logging and software. For pultrusion, Pultrex makes machinery for thermoset and thermoplastics processes, with pull force of 3-24 tonnes. Auxiliary equipment includes pull winding and mat slitting machinery, Geltex analyzers, data acquisition, dies and preforming in-feeds. Booth H21.

Vacuum bagging process materials and consumables

Leadgo-tech (Shanghai, China) is featuring its line of vacuum bagging process materials for the wind, aerospace, marine, and other end markets. Headquartered in Shanghai, with manufacturing in Ningbo, China, and branch offices in Europe and North America, Leadgo-tech supplies vacuum bagging film, peel ply, release film, breather, infusion mesh, sealant tape and pressure-sensitive tapes, among other products. Booth Q56.





Empowering the world to

CONCEPTUALIZE, MANUFACTURE AND IMPLEMENT

advanced composite solutions.







Visit us at CAMX: Booth F57

Composite Structures

Automation Equipment

AEROSPACE • DEFENSE & MILITARY • OIL & GAS R & D • AUTOMOTIVE • INDUSTRIAL

automateddynamics.com +1 (518) 377-6471

Join us on LinkedIn and Twitter for all the latest news and updates!



Composites design, engineering and fabrication services

Quartus Engineering (San Diego, CA, US) is emphasizing its advanced engineering services for the design, analysis and manufacture of aerospace, mechanical and optical systems using computer-aided technologies. Quartus can provide complete system design, address specific design/analysis needs, or integrate with a team to provide increased capabilities or bandwidth. Simulation capabilities include structural (FEM, dynamics, non-linear, etc.), thermal, optical, aerodynamic (CFD, aeroelasticity, vibro-acoustics) and more disciplines. Quartus Engineering offers services to transition products from concept through to manufacturing in its 23,000-ft² facility, including five Class 10,000 cleanrooms for optical assembly integration and test. The company's portfolio includes products ranging from astronomical telescopes to multispectral zoom imagers, satellites, aircraft and launch vehicles, space-based laser communication systems, LIDAR, medical devices, consumer products and more. Booth G45.

Nanofiber detection system

Stat Peel Inc. (Sandy, Utah, US; Glarus, Switzerland) is exhibiting its nanofiber detection system, the Identifier C1. The Identifier C1 is designed to recognize airborne carbon nanotubes, graphene and other particles and is able to



distinguish these materials from harmless background particles present. According to the company, CNTs and graphene are promising additives in composite materials due to their strength, superior conductivity and light weight, and monitoring exposure of these potentially harmful fibers and platelets is important in any occupational environment to avoid contamination and reduce risk to workers and facilities.

Stat Peel's system uses sensor, spectroscopy and data analytics technology. To use the system, employees wear lightweight badges that filter air to collect respirable airborne CNTs. Each badge holds a miniature filtration membrane. After a shift, badges are inserted into the benchtop-sized reader, which selectively detects CNTs using Raman spectroscopy and reports and stores individual exposure. The badges can also be used for stationary sampling to collect release data in different areas of a facility. Booth Y66.



Joe Jansen - National Sales Manager - Phone +1 715 680 8008 · joej@roth-usa.com www.roth-composite-machinery.com · info@roth-composite-machinery.com

Optical transmission scanner for NDT

General Photonics (Chino, CA, US) is introducing the OTS-1000 optical transmission scanner for nondestructive testing. Using ultraviolet (UV), visible (VIS) or near Infrared (NIR) light sources, the OTS-1000 provides fast, 100-micron resolution, quantitative analysis of glass fiber composites. General Photonics says the OTS-1000 is capable of subtle analysis because the detection method relies on optical density of the sample, not the mass density or mass thermal density. The optical density correlates to the chemical structure of the sample, which means that just as a spectroscope can detect different chemicals by their spectral lines, the OTS-1000 can detect different resins and matrix structures by their optical signature. The company also is announcing a series of general purpose application packages for analysis; with it, users can develop specialized application programs for their own testing needs. At CAMX, the company will scan various composite samples to demonstrate the speed and accuracy of the instrument and to display the output from beta versions of the application programs. Booth L85.

Styrene-free, low-VOC resins and adhesives

Andara LLC (Sheboygan, WI, US) is featuring its line of styrene-free NOVOC resins for use in coatings, composites and other applications. NOVOC resins contain no volatile organic compounds (VOCs) or hazardous air pollutants (HAPs) and are non-flammable and low odor while maintaining superior performance. Andara is introducing three new products at CAMX. NOVOXY 9000 Series is a low-color, UV-resistant epoxy that offers high hardness (Shore D 84), easy application and clarity. It is available in benzyl alcohol-free and nonal-phenol-free versions. NOVOC 600 foam system is a closedcell, moisture-resistant, rigid, elastomeric foam suitable for use in cores and sandwiches. NOVORTIC 200 adhesive is a side-by-side, two-component, UV-stable, chemical-resistant adhesive with 100% solids and good weatherability. Booth DD19.

Oven curing technologies

International Thermal Systems (ITS, Milwaukee, WI, US) is featuring its line of out-of-autoclave curing systems, including a custom-configured oven, integrated multi-port vacuum system and process controller that offers the ability to maintain temperature uniformity at $\pm 5^{\circ}$ C. ITS' ovens include multi-part thermocouple and vacuum systems that meet NADCAP, AS9100 and AMS2750E standards. Booth R39.



REGISTER TODAY AND SAVE!

CW 2018

CompositesWorld

CARBON FIBER

DECEMBER 4-6, 2018 | LA JOLLA, CA USA **HYATT REGENCY LA JOLLA**



to connect with thought leaders in the carbon fiber composites industry!

2018 CONFERENCE CO-CHAIRS:

ERIC HAISS Executive Vice President Continental Structural Plastics

MERLIN THEODORE Director, Carbon Fiber Technology Facility Oak Ridge National Laboratory

KEYNOTE PRESENTATION BY:

BRETT SCHNEIDER

President, Global Fibers | Hexcel Corporation









PRESENTED BY:





Early-bird special! Register by October 23 and SAVE \$400! CarbonFiberEvent.com

SPONSORED BY:















E-glass and hybrid fabrics, core materials

Parabeam BV (Helmond, The Netherlands), part of Canadian ZCL Composites Inc., is featuring its Paraglass and Paratank 3D E-glass and hybrid fabrics, as well as its Hssue fiberglass sandwich system. Parabeam says its products are targeted toward core applications in end markets that rely on factors such as weight, impact resistance, thermal insulation, acoustic damping or strength. Parabeam's fabrics, combined with phenolic resin, reportedly meet performance standards like BS 6853, NFP 92501 (values M1 and F0) and EN 45545-2. Combined with polyurethane resin, the laminate becomes permanently flexible and offers significant durability. Parabeam also notes that its fabrics can be combined with foam epoxy to create lightweight panels. Standard sandwich thickness ranges from 0.118 to 0.866 inch; custom thicknesses are also available. Noted applications for Parabeam's materials include tank liners, aircraft interiors, prop blades, public transport interiors, cladding and walls for construction, or marine superstructures. Booth J30.

Composite tooling and parts fabrication

Nor-Ral Inc. (Canton, GA, US) is featuring its capability to manufacture composite parts and tools. Nor-Ral has experience with glass fiber, carbon fiber and Kevlar prepregs, as well as vacuum-assisted resin transfer molding (VARTM) tooling using glass and carbon fibers. Nor-Ral operates two autoclaves, with the largest measuring 8.5 by 30 ft. Nor-Ral also has a full precision machine shop on site with multiple 5-axis and 3-axis machines. The company's largest 5-axis machine has a working envelope of 22 by 16 by 6 ft. Nor-Ral is NADCAP accredited. Booth CC52.

Rolls, idlers and sensors

Maxcess (Oklahoma City, OK, US) is representing, in Booth H59, an array of technologies from Fife, Tidland, MAGPOWR, Webex, Valley Roller, Menges Roller and Componex. Technologies and parts on display include:

- Webex and Menges Roller: Heat transfer, vacuum and idler rolls
- · Valley Roller: Rubber compounds
- · Componex: WINertia dead shaft idlers
- · Fife: Sensor technology
- · Tidland: Control Series Electronic Knifeholder
- MAGPOWR: DLCA-NET tension amplifier with networking capabilities.

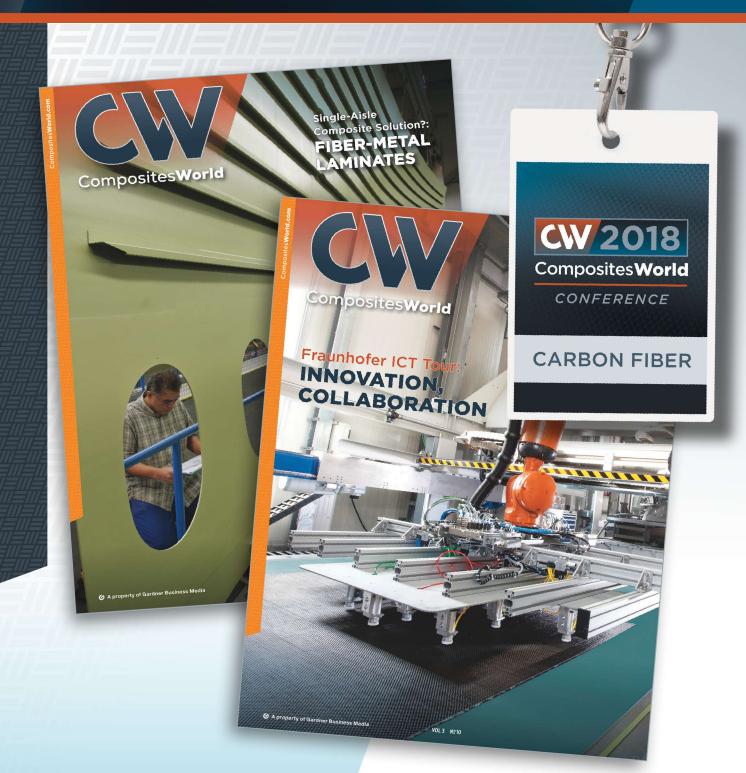




SUBSCRIBE TODAY.

compositesworld.com

CW is CompositesWorld!



High-temperature, easy-to-apply, rebondable adhesive system

ATSP Innovations Inc. (Champaign, IL, US) is exhibiting its new line of ultra-high temperature resins (aromatic thermosetting copolyester - ATSP) for coatings, composites and stock shapes. Featured is ATSP's Self-Bond adhesive material. Self-Bond reportedly enables rapid bonding (less than 5 minutes), low mess and non-tacky high-temperature adhesion (28 MPa pulloff strength at 25°C, 4 MPa at 340°C). Self-Bond resins can be deployed via electrostatic powder deposition, allowing adhesive deposition rapidly over broad areas. In addition, Self-Bond allows two articles coated with ATSP to covalently bond to each other as solids throughout the entire process via bond exchange reactions. Other features of Self-Bond include touch-safe, non-tacky open time and an entirely solidstate process, meaning it is odor-free with no VOCs. Additionally, Self-Bond resins are rebondable, so long as the resin failure mode is cohesive rather than adhesive. ATSP Innovations also provides NOWE wear solutions for extreme environments. NOWE uses a blend of ATSP polymer with discontinuous carbon fibers and solid lubricants. NOWE bearings and stock shape materials are said to offer good wear properties, low coefficients of friction, working temperatures ranging from cryogenic to 300°C, oxidative stability, low moisture pickup, non-flammability, machinability with low dust production and compatibility with Self-Bond. Booth E80.

CT-based metrology software

Volume Graphics's VGSTUDIO MAX software performs precise metrology tasks, compares parts with their nominal CAD model and detects discontinuities based on CT data. The latest version, VGSTUDIO MAX 3.2, offers new

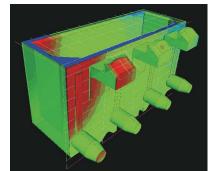
options for tool and geometry corrections and a more meaningful assessment of mechanical effects of porosity. It also allows users to predict how much force a part could theoretically withstand, solely based on a CT scan. The software offers analysis, simulation, and visualization tools.

ization tools.

The software's optional

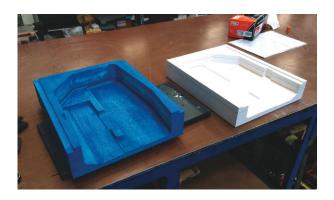
Manufacturing Geometry

Correction Module combines



the manufacturing, testing, and correction of tools and components into a seamless digital workflow. It is said to be a cost-effective, easy-to-use and versatile method for tool correction, surface reconstruction of a manually reconstructed tool and part correction of 3D printing geometries. The optional cutting-edge Structural Mechanics Simulation Module helps users take the results of a porosity analysis into account in a structural mechanics simulation. Booth L30.





High-temperature, low-CTE tooling board

Compotool (Monroe, WA, US; Auckland, New Zealand) is featuring its inorganic tooling board made from specialized formulated calcium silicate materials that reportedly exhibit favorable thermal and process characteristics. This tooling board is said to be thermally stable and able to withstand temperatures of more than 1,000°F with minimal thermal conductivity. The board has a theoretical coefficient of thermal expansion (CTE) of less than 3.3 x 10⁻⁶ F⁻¹. The material's low thermal conductivity, says Compotool, reduces oven or autoclave cycle time while energy requirements are relatively low. The Compotool tooling boards are available in high-density (55 lb/ft³) CT850, medium-density (47 lb/ft³) CT750 and low-density (18 lb/ft³) CT300. These densities are formulated to be easy and fast to machine to high accuracy. Cutting is similar to wood and the material is nonabrasive, resulting in minimal tool wear. The different densities can be used in combination to reduce overall cost and weight. Compotool also provides matching hightemperature adhesive and sealing systems that allows users the ability to build mold shapes that can be used for either a master model or for short run direct molds. Compotool tooling boards are compatible with resin systems that require high processing temperatures such as cyanate ester, benzoxazine, bismaliamide, polyamide and thermoplastic systems. Booth M43.

Non-traditional machining process supports range of materials

IKONICS Advanced Materials Solutions (Deluth, MN, US) is showcasing its Precision Abrasive Machining (PAM), a non-traditional machining process. PAM supports a range of materials such as carbon fiber, glass fiber, Kevlar, ceramic matrix composites (CMCs), silicon carbide, sapphire, glass, alumina, graphite and more. The process reportedly enables perforations in any shape and with clean edges, high-precision repeatability, fewer stresses or defects, complex curve capabilities and flexible and rapid design changes. No secondary machining services are needed. Suitable applications include engine liners, thrust reversers, blocker doors and other parts that require hundreds or thousands of perforations. PAM is said to provide a high degree of accuracy and repeatability within 50 microns, as well as fast turn-around and prototyping for design changes. Booth G90.



Composite product and process development assistance

The Composite Development Centre of Québec (CDCQ, Québec, ON, Canada) is featuring its services, designed to help businesses and organizations that are part of the composites value chain with applied research services, technical assistance and information activities, improving the quality and performance of their products. The center includes a multifunctional laboratory with equipment covering the majority of composites fabrication processes, and a material characterization and testing laboratory, accredited to ISO 17025. The CDCQ is a College Center for Technology Transfer (CCTT), recognized by the Québec government and affiliated to the College of Saint-Jerome. The center has developed a niche in green composites, including composites recycling (glass and carbon fibers), valorization and long-fiber thermoplastics. Services include applied research; material, process and equipment selection; process development, optimization and start-up; troubleshooting; molding trials and prototyping; 3D printing (prototype molding); materials characterization; and training. Booth CC49.

Machine-independent programming, simulation, control software

Machine control and software specialist **CGTech** (Irvine, CA, US) is demonstrating Composites 8.1, the latest version of its VERICUT Composite Programming (VCP) & VERICUT Composite Simulation (VCS). Composites 8.1 features a redefined graphical user interface (GUI), an enhanced suite of programming and analysis tools, and redefined methodology through the use of a new Laminate Manager. In addition to organizing files, the Laminate Manager brings clarity and visibility to the laminate as a whole. This laminate overview, says CGTech, has made several other new enhancements possible, like batch processing, laminate-wide analysis and intelligent ply generation.

CGTech is also featuring its latest version of VERICUT 8.2, CNC machine simulation, verification and optimization software that enables users to eliminate the process of manually proving-out NC programs. VERICUT simulates all types of CNC machining, including drilling and trimming of composite parts, water jet cutting, riveting, robotics, mill/turn and parallel kinematics. Visitors to CGTech's booth will also get information on new projects that highlight the use of machine-independent, offline NC programming software for automated fiber placement (AFP) and automated tape laying (ATL) machines, such as the work being done at NASA's Langley Research Center using a 16-tow Electroimpact AFP machine. Booth BB28.

51

Composites solutions for automation, preforming

Schmidt & Heinzmann is featuring a range of composites equipment and manufacturing services. For example, it offers a variety of technologies for the cutting, dosing and distribution of brittle, ductile, visco-plastic and natural fibers. According to the company, almost any kind of fibers that are feedable up to 10,000 tex can be cut. Robust, high-quality wide roving cutters for chopping brittle fibers are maintenance-friendly and low-wear, with cutting lengths of 4-50 mm. A newly developed, high-performance fiber cutting system, called FiDoCut, cuts various types of fibers simultaneously in industrial quantities. It can cut most kinds of dry fiber up to 4,800 tex. The company also offers automation services and expertise including automatic rewinding and cutting units for small and big rolls or festooned material; a range of machines for automated cutting, weighing and stacking; preforming solutions; automated solutions for cooling, deburring and cleaning of FRP parts; and bonding with fully automated handling and process control.

In composites engineering, the company has experience setting up equipment for SMC or CF-SMC semi-finished material, part production for SMC or CF-SMC parts, defining and producing preforms, and defining bonding processes and production systems. Full composites engineering services include planning of the entire SMC or CF-SMC material production; planning of the production of SMC or CF-SMC parts; governmental approval processes; explosion protection and fire safety expertise; definition of equipment parameters to achieve product targets; definition and simulation of production processes before production; and calculation of cycle time, output and performance. Booth J17.

Site selection services

Morrow Hill LLC (Dallas, TX, US) is emphasizing its leasing, development and purchase solutions that help clients find suitable property and facilities for manufacturing. Morrow Hill only represents tenants, never landlords, which the company says gives it unbiased access to all available property. Its brokers have experience with properties ranging from distribution and manufacturing facilities to cold storage and data centers. It will negotiate terms, communicate with municipalities and economic development boards, map shipping and supplier hubs, as well as the most efficient trucking routes. Morrow Hill will also assess power requirements, zoning, economic incentives, fleet requirements, rail access, warehouse design, tax and trade benefits and airport and port access. Booth CC21.



A clean technology for clean, zero-emissions buses

Monocoque composite body designed to support all bus loads.

By Donna Dawson / Senior Writer Emeritus



>>> Proterra Catalyst battery-electric buses already have logged more than 4 million miles of zero-emission and — no small benefit — foul-fume-free service in public and commercial transit duty. Behind that green success is a structural design by Proterra Inc. (Burlinghame, CA, US) with TPI Composites Inc. (Warren, RI, US), in which all loads are supported solely by a monocoque composite structure. Minus the conventional steel frame, the buses are lightweight enough to offer operators a nominal range of 350 miles on a single charge.

Composites technology enables performance goals

"A transit bus can log hundreds of miles each day for 12 years up to 20 years, so we needed high strength, low weight and durability," says Joshua Stewart, Proterra director of customer engineering. "The composites technology enables those goals."

Catalyst boasts an acceleration from 0 to 20 mph in 4.5 seconds

(an important asset for a bus merging into traffic); a curb weight of 26,000-33,000 lb (11,793-14,969 kg), claimed to be the lightest in its class; and a climb gradeability of 15.5%, or 8°. (*Gradeability* refers to the percent of slope, or the steepest incline, the vehicle can climb from a standing start.) Further, the composites design offers unmatched corrosion resistance.

Stewart notes that another substantial benefit of composites is safety in a collision. Automotive composite pioneer Gary Lownsdale, now owner of consulting company TransTech International Inc. (Loudon, TN, US), tells us how it works: "Though the damage mechanisms comparing metals

FIG. 1 All-electric buses with composite bus bodies

A Foothill Transit (West Covina, CA, US) Proterra Catalyst 40-ft bus in its docking station; the charging arm connects with the contacts on top of the bus to recharge it. Foothill plans for all-electric buses by 2030 on its routes carrying 14 million people annually over 300 square miles, serving 22 cities plus downtown Los Angeles in Southern California's San Gabriel and Pomona Valleys.

Source | Foothill Transit

and composites are complex, in general, we can say that metals deform in a linear fashion and pass the energy wave through to the next structure, causing serial failure (breakage). Composites, on the other hand, deform in a nonlinear fashion." Advantageously, they can be designed to deform predictably and then fail in a specific mode, which enables the designer to tailor the energy absorption via selective use of the matrix. Lowsdale suggests one way to look at this is to compare force vs. deflection curves for metals and composites. With metals, there is a straight line (linear curve) until the material's ultimate tensile strength or yield strength is reached. Then there is a sharp drop off as the material fails and energy is released. This curve is roughly the same at both high and low strain rates. "With composites," he notes, "the material's curve continues to rise well above that for metals and then gradually tapers off as failure begins and energy is released." The area under each curve is the amount of energy that can be absorbed in a crash. And if one is laid over the other, the compos-

The buses are lightweight enough to offer operators a nominal range of 350 miles on a single charge.

ite's curve is much larger, indicating that the composite can absorb much more energy in a crash and that it can do this at much higher strains and at much faster

rates. "The ability to absorb more energy at a given force and over a given distance," Lownsdale concludes, "is a big advantage of composites."

Manufactured by low-emission SCRIMP

To establish material and process parameters, the design team conducted extensive finite element analysis (FEA), using ANSYS (Canonsburg, PA, US) simulation software for the body structure, in addition to sample validation testing. E-glass fibers in stitched noncrimp fabric (NCF) and unidirectional (UD) carbon fiber NCF materials, in a vinyl ester resin closed infusion molding process, were selected to best meet mechanical requirements and environmental conditions, such as weather and ultraviolet (UV) light.

TPI manufactures the bus bodies using the Seeman Composites Resin Infusion Molding Process (SCRIMP), a customized upgrade of vacuum-assisted resin infusion developed for making high-quality, repeatable composite parts with nearly zero VOC emissions. TPI engineering manager Brian Lucchesi says TPI has been producing large structural composite components with this method for more than 25 years. He notes that tests have verified its workplace safety, noting that "VOC emissions of 0.2 to 0.6% from TPI's SCRIMP process have been observed and confirmed by the Rhode Island Department of Environmental Management."

TPI also manufactures all its own tooling, including multi-piece composite molds supported by a structural steel framework.

The bus is built in four basic sections using the same materials and manufacturing process, in a mix of solid laminates and





FIG. 2 Infusion of bus body, upper and lower

Upper bus body layup (top) and lower body layup (bottom), ready for infusion.

sandwich structures with a balsa wood core. The bus body consists of the *upper body* from the roof down to the lower edge of the windows, which includes the entire windshield and rear window geometries; and the *lower body* from the lower window line down to the floor, which includes all structural chassis geometries for vehicle subsystem attachments. (Fig. 2)

The roof consists of one upper fiberglass structural sandwich molding down to the window line, and another for the lower (ceiling) geometry.

Manufacture generally proceeds as follows: First down in the mold is a gel-coat layer to produce a smooth, appealing exterior. Dry fabrics are then manually arranged in the mold: Triaxial (0°, ± 45 °) fiberglass reinforcements provide longitudinal and torsional stiffness for the main global plies. Unidirectional (UD) carbon fiber NCF strengthens window frames and the A-pillars that attach the

>>



FIG. 3 Bonding of roof and bus body

Roof and bus body subassemblies are permanently bonded together into a monocoque structure that supports all bus loads. Source | TPI

roofline to the lower body and surround the windshield. Carbon fiber, with its high stiffness properties, reduces window and door opening displacements, thereby minimizing the kind of distortion that could lead to fracturing of the glass. Quadriaxial $(0^\circ, 90^\circ, \pm 45^\circ)$ quasi-isotropic fiberglass material is used where high strength and stiffness are especially critical, notably where suspension components interface, where mirrors and lights and other exterior elements are connected, and in areas subject to

high compression — for example, where airbags interface with the body and at the major drive-axle connection.

The layup is vacuum bagged, infused with a catalyzed vinyl ester resin system and cured at room temperature.

Interior components and attachments

Interior composite panels in wheel well boxes (which provide storage areas for electronic equipment), structural composite





CW

floor components, metallic plates and inserts, and other interior components are bonded into roof and body primary sub-assemblies before they are bonded together.

Bus doors are still aluminum; however, some of Proterra's suppliers have composites versions in the works, Stewart says, adding, "we hope to be the first to have them."

Doors and other interior components are attached using Proterra's proprietary composite mounting brackets, adding an

+ LEARN MORE

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

extra strength-to-weight advantage. The brackets are attached either by molding stainless steel inserts into the laminate, or by bonding.

For attaching the doors,

hat brackets are bonded onto the adjacent body, with stud plates embedded into the brackets. The door structure is mounted to the stud plates. "This is not only convenient, it is a dimensional aid for correct door positioning every time; there's no guesswork in the install," Stewart says.

Bumpers currently are also primarily aluminum structures with reaction injection molded (RIM) plastic covers, he adds. Bumpers are attached to the body by bolted hat brackets.

Methyl methacrylate (MMA) adhesive is used for all bonding processes. The cured sections of the roof and body are adhesively bonded together to complete those sub-assemblies and the sub-assemblies are then adhesively joined for a permanent bond to create the finished product.

Better and less expensive than

More than 140 of the buses, a mix of *Catalyst FC, XR* and *E2* 35- and 40-ft models, were on the road by year-end 2017 in communities across the US from Washington state to Florida. That number is expected to double in 2018. "We're expanding our production capabilities to meet existing sales and projected demand," says Stewart,.

In addition to the emissions advantages, and the high mileage between charges afforded by the lightweight composite bus body, the Proterra/TPI design also reaps financial benefits. Factoring in fuel and maintenance cost savings over the lifetime of a vehicle, Proterra calculates its buses save transit agencies US\$448,000 during a 12-year service life compared to diesel alternatives (about \$2.36/mile compared to US\$2.83/mile). cw

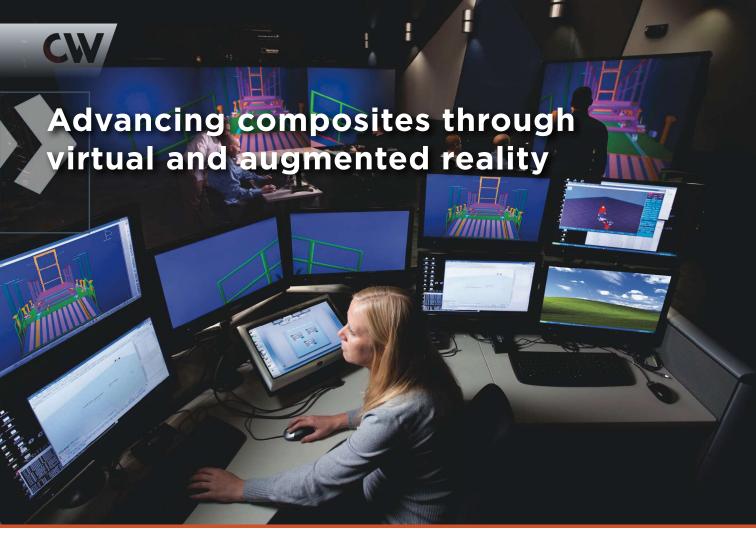


ABOUT THE AUTHOR

Donna Dawson is *CW*'s (previously) retired senior writer emeritus, now residing and writing in Lindsay, CA, US, in the foothills of the Sierras. donna@compositesworld.com







A review of technologies that are bridging the technical divide between the virtual world of design and simulation, and the real world of composites manufacturing and repair.

By Karen Mason / Contributing Writer

>> Virtual reality.

It's a term many associate with the fictional worlds created in movies such as The Matrix and the playgrounds found in today's sophisticated computer games. Since the early days of CAD, engineering and manufacturing, composites engineers have used sophisticated software to create accurate virtual representations of advanced

composites products and technologies. It could even be argued that virtual reality is simply an outgrowth of these virtual technologies that have long serviced the industry.

From monitors to

CHIL moves 3D models from

monitors to a virtual environ-

ment, where engineers can

perceive and interact with

life-size 3D models.

Source: Lockheed Martin

immersion

But what makes virtual reality and associated technologies distinct is the interaction they provide between virtual and actual worlds. Developed to enable filmmakers and video game developers to capture the movements of live actors and insert them into animated film and video formats, virtual reality (VR) applications today can, for example, enable an engineer or technician fitted with strategically placed body sensors to become immersed in a virtual manufacturing environment — perceiving and interacting with lifesize, 3D models of prospective machines and systems, future components or assemblies, or become part of a virtual manufacturing floor and move about the environment as digital avatars. In these and other practical ways, composites design and manufacturing engineers have reaped and are more widely reaping many benefits from VR technologies.

Further, they are developing technologies that *mix* the virtual and actual manufacturing realms. Admixtures of the virtual and actual provide additional sets of applications. Typically categorized as "augmented reality (AR)" or "mixed reality," these applications vary in the degree to which virtual and actual elements play a part. On one end of the spectrum, "augmented virtuality" might describe a 3D digital model onto which images and data from an actual component are superimposed, such as actual ply images from an automatic inspection system, showing deviations from the nominal of ply boundaries, fiber orientation and the like. On the other end, an augmented reality application might enable a technician to "see" under-surface laminate damage, accurately located on the actual component, as he or she looks through virtual glasses.

The range of VR/AR technologies, their developmental and readiness levels, and their implementation and acceptance in the composites industry, widely vary. So, too, do the particular areas to which the technologies apply, from advanced virtual prototyping through the entire product lifecycle to maintenance and repair operations.

The benefits that result from these VR/AR leaps include reduced development time, reduced risk, lower manufacturing costs and shorter cycle times.

Immersive product prototyping

Since the advent of computer-based virtual prototyping, composites designers and manufacturers have saved untold development costs and enabled greater part optimization because a part design could be modified without the attendant time and cost penalties of building a new physical prototype. Those early adopters are enjoying even greater advantages as they implement VR prototyping technologies.

Lockheed Martin's (Bethesda, MD, US) foray into VR technology, which the company is using for prototyping as well as evaluation of manufacturing processes, is housed at its Collaborative Human Immersive Laboratory (CHIL, Denver, CO, US). One of the largest such facilities in the world, CHIL reportedly saves Lockheed Martin more than US\$10 million annually in its spaceflight, satellite and solar-array programs, according to the lab's manager, Darin Bolthouse. Making the investment that much more financially sound, Lockheed Martin has kept costs down at CHIL in part by employing standard consumer devices, such as the Oculus VR (Menlo Park, CA, US) Rift headset.

With computer-based CAD and simulation programs already providing sophisticated graphical representations, Bolthouse believes VR is the logical next step. "We've got this wealth of 3D data already out there," he points out. "The ability to bring that into an immersive VR environment allows our engineers to see that in full scale."

CHIL includes two primary VR approaches, the first of which is used for VR prototyping. Called a CAVE (cave automatic virtual environment), this VR approach uses wall-sized displays to generate full-scale 3D models of components, systems or assemblies that appear to "float" holographically in space as engineers view them through 3D glasses. The 3D images can be rotated and

repositioned, giving the engineers the ability to view all aspects from any angle.

Several other VR prototyping applications are employing a virtual reality system from the ESI Group (Paris, France) called IC.IDO. The company describes IC.IDO as a VR solution that combines "high-end visualization and real-time simulation of product behavior in its actual size." To produce its CAVE, the IC.IDO system includes stereoscopic projection hardware directed at multiple "powerwalls." Users wear 3D glasses to experience lifesize renditions of the prototypes they are developing.

Helmut Dietz, head of digital manufacturing at Bombardier Transportation (Montréal, QC, Canada), reports that the IC.IDO »



■ Virtual manufacturing floor

Lockheed Martin's Collaborative Human Immersive Laboratory enables participants to assess manufacturing floor and equipment plans in a virtual environment before the company invests in the actual shop floor. Source: Lockheed Martin



On-screen layup guidance

Anaglyph's PlyMatch system displays the actual layup overlayed with virtual guidance. A technician views the layup and guidance on a monitor as he positions the next ply. Source: Systima Technologies



Virtual overlay on actual layup

PlyMatch monitor accurately displays where to position the next ply to be laid up.

systems his company employs can save up to 70% on prototype costs. CAD data from the company's CATIA V5 design system feed into the VR system to produce the 3D images for the CAVE. "In the end, we can view the developed vehicle on high-resolution powerwalls — and even touch it," says Dietz of the IC.IDO experience. "This way, development and installation steps can be accelerated, optimized or done away with entirely."

Virtually verifying workcell/worker fit

A VR CAVE can be used for virtual interaction not only with prototypes, but also with whole manufacturing and assembly lines, and ESI's IC.IDO is also being used for these applications. Safran Nacelles (Le Havre, France) applied its 4m-wide by 2.5mhigh, two-wall IC.IDO CAVE to evaluate its Airbus A330 nacelle production line. The A330 nacelle features an innovative onepiece composite inner structure. Because engineers could accurately visualize the tooling needed before ordering hardware, Safran engineers reduced the nacelle's development cycle from 60 to 42 months. Equally as significant as the time savings was the economic value of the VR system, reports Nicolas Lepape, Safran Nacelles' research and technology project manager for virtual and augmented reality. "The typical cost of creating a virtual reality CAVE is €100,000 to €200,000 - which is equivalent to the average price of one major piece of tooling for a final assembly line," he points out.

Back at Lockheed Martin's CHIL facility, in addition to the company's CAVE, a second VR approach enables engineers, as noted above, to enter and interact with the virtual world by

donning an array of body sensors and standing in a motion-capture area. The advantage here is the ability to directly check, for example, something as simple — but as time- and cost-critical — as whether a fastener position can actually be reached by an installer within an assembly. By analyzing design and manufacturing processes in the virtual world before building physical facilities and components, CHIL enables engineers and technicians to analyze, evaluate and modify systems and processes when the expenditure of time and the financial investment for the latter will be at its lowest. Additionally, VR evaluation enables Lockheed Martin to easily and inexpensively maximize worker safety and productivity by developing ergonomically sound manufacturing cells and equipment.

CHIL evaluates all stages of the product development lifecycle for Lockheed Martin systems, so application to composite components is part and parcel of the broader program. One recent CHIL evaluation was performed on the main propulsion fuel tank for the company's new LM 2100-series satellite bus, which is a major redesign of the company's proven A 2100-series.

"We used CHIL to make sure we could install the tank," explains Andrew Bushell, senior manufacturing engineer at the company's John C. Stennis Space Center in Mississippi, US. The 117 cm-diameter metal tank with composites overwrap plays a critical role in meeting goals of decreased production time and costs for the new series.

"There were questions about reach, fit and line of sight," Bushell recalls. "It was very helpful to get a feel, ergonomically, of what we were up against. We have drawings and dimensions, but you don't have a true appreciation until you have it in virtual reality." Bushell notes, for example, that the VR motion-capture system was used to test whether a technician could reach a high-torque bolt and, with arm extended, operate the torque wrench safely and effectively. Bushell adds that the composite overwrap required special attention during the VR simulation. "We looked at all our surface contacts and made sure there was no direct contact with the composite overwrap, to protect it from scratching." (In an interesting sidelight, since the LM 2100 tank was moved into production using conventional manufacturing methods, Lockheed Martin also has qualified a 3D-printed version of the tank for space flight.)

Lockheed is currently using CHIL to develop AR applications for its space programs, and the facility has hosted investigators from other business units to perform evaluations and to collaborate on VR/AR advancements and applications across the Lockheed Martin technology spectrum.

An application of VR manufacturing floor design at the Airbus Broughton, UK facility assists engineers there in the validation of composites manufacturing methods and process improvements required for the A350 XWB aircraft. Its wing is built in a horizontal, rather than the more common vertical, configuration. Airbus wanted to prove it could build the wing this way before investing in the tooling. "They wanted to simulate the whole assembly process in a virtual environment," recalls Julian Ford, business development manager at VR supplier Virtalis (Manchester, UK).

Airbus chose the Virtalis ActiveWorks VR suite for this application. Geoff Tantum, then the engineering group leader for

simulation at Airbus UK, selected ActiveWorks in part because of its ability to interact seamlessly with the facility's Dassault Systèmes (Vélizy-Villacoublay, France) product lifecycle management (PLM) software. "We wanted a system that would take our CATIA and DELMIA PLM data and turn it into a 3D VR model automatically, without any need for translation," he recalls.

The benefits that result from

and reduced risk.

VA/AR in composites include

reduced development time

Virtalis demonstrated that its system could perform as required before Airbus invested in it. Unfortunately, Ford says, Airbus discontinued the application after Tantum left the company - an example of the obstacles VR technology may continue to face before

more composites industry personnel are familiar and comfortable with the technology. "It's disappointing," Ford says, "but we continue to seek manufacturers where we can deploy visualization technology across the enterprise."

Beyond templates and laser projection

While VR technologies enable composites engineers to enter the virtual realm, AR technology is bringing the virtual realm to the actual manufacturing floor. Presaging AR functionality, the first tool to make this direct virtual/actual connection was laser projection, which was introduced to the composites industry in the late 1980s. Laser projection systems import CAD data and

use it to generate and project patterns accurately into 3D space. These patterns most commonly are used as templates, projecting onto a tool the outline of a ply to be laid up. They also are used to indicate correct fiber orientation, display where holes are to be drilled, pinpoint foreign objects and debris (FOD) based on automatic inspection data, and other functions requiring projection of virtual information into 3D manufacturing space.

Taking the opposite tack, and falling somewhere within the spectrum of mixed reality applications, the Anaglyph Ltd. (London, UK) PlyMatch system projects 3D manufacturing space into the virtual realm. Specifically, PlyMatch provides a live feed of the work area, which is displayed on a monitor along with a super-imposed, computer-generated image of each ply to be laid up. The ply software image is generated from a CAD or design file and, because PlyMatch is self-calibrating, the images match up accurately, even when the camera or tool is moved. After an initial calibration, which takes only a few minutes, an optical sensor tracks the relative positions of the camera and tool, and the system's

controller updates the positional relationship in real time. The system is reportedly compatible with any CAD application that generates IGES or 3D DXF files. Alternatively, it can be used with Anaglyph's proprietary composites design and analysis software, Laminate Tools, or with compatible layup data files produced

> by CATIA Composites Link (Dassault Systèmes, Vélizy-Villacoublay, France) or Fibersim (Siemens PLM Software, Plano, TX, US).

Applied Composite Engineering (ACE, Indianapolis, IN, US) has used PlyMatch to guide the company's manufacture of a heated inlet for helicopter anti-icing system (see Learn More, p. 62). More recently, Systima

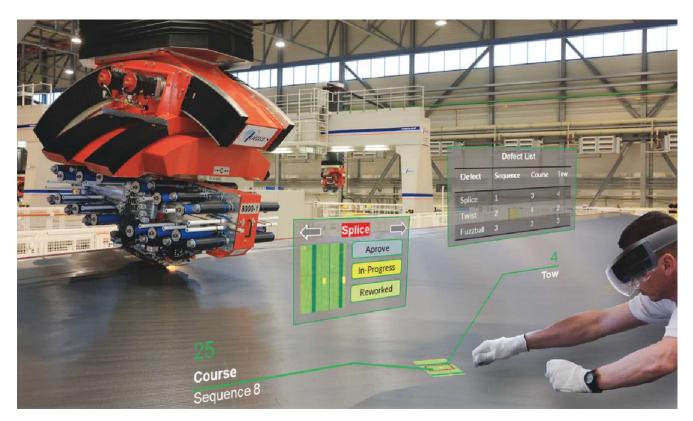
Technologies (Kirkland, WA, US), a maker of energetic systems and components primarily for defense and space applications, put PlyMatch to work when the company brought composites manufacturing in-house in 2014. That's when Eric Wightman came on board as director of structures and advanced materials, a depart-

by ACE, Wightman recognized that the technology was a fit for the kind of work Systima would be doing. "We're not a build-to-print shop; we're a design firm," he says, noting that, for a large majority of its projects, Systima builds only first articles. Many of these are

ment that has grown from a one-man operation to a staff of 12. Having previously worked with PlyMatch when he was employed long and narrow and feature complicated geometries. For example, >>







Addressing defects in real time

InFactory Solutions VisinPro application, under development, uses AR glasses to pinpoint a defect on the actual production surface, along with information that assists the technician in remediating the defect. Source: InFactory Solutions

a nose cone developed for a hypersonic application is about 175 cm long with a diameter of about 63 cm. It is laid up in two halves, using a female mold. Wightman found that a laser projection system just wouldn't work effectively or cost-efficiently with these geometries. "We would have needed three or four projectors, and calibration would have been much more involved," he says. Such a system also would have had a six-figure price tag, where Systima's PlyMatch implementation cost less than US\$50,000.

Further, using PlyMatch, manufacturing the nose cone and similar components has proven efficient and straightforward, Wightman asserts. Systima designs its products using CATIA, then exports an IGES file to the PlyMatch system. When the composites staff is ready to build a component, an operator performs PlyMatch's initial calibration and is ready to begin layup in less than 5 minutes. Even positioning of plies while looking at the monitor is said to be straightforward— Wightman contends that an operator who already knows how to perform layup can be trained and proficient with PlyMatch in an afternoon.

Systima has built components using PlyMatch from the start, so Wightman does not have comparative data; but he estimates that layup of a complete flight set (two halves) would take at least twice as long as the current three weeks if it were performed using templates and ply books. He also emphasizes how important it is that the system has resulted in accurate, timely layup of flight-critical parts. "In hypersonic programs, it is imperative to get it right.

Raw materials alone may be worth US\$30,000 per nose cone, and there may be 1,700 pieces in one ply kit."

The PlyMatch system reportedly also can locate manufacturing or assembly-sequence features, such as inserts or bolt holes. Additionally, the complete build process can be digitally recorded to an .avi file, providing a record of each individual component, as built, and showing any deviations from nominal ply position or fiber orientation. For automated manufacturing, PlyMatch has the potential to be adapted to record machine movements and material placement relative to the nominal.

Anaglyph says it continues to upgrade PlyMatch, adapting new hardware technologies and software upgrades as they become available. Emmanuelle de Posson, marketing manager at Anaglyph, mentions camera and lens technologies, PC interfaces and PC peripherals as examples, and adds, "Currently we are working towards a totally wireless version, which is a challenge, given the requirements for long battery power and no loss of video picture quality." Anaglyph also is working on methods to effectively accommodate larger tools and layups with sufficient accuracy and alignment. Additionally, a version of PlyMatch that uses an AR headset device is in development.

Virtually mapping rework and repair

Another major player in AR for composites applications is InFactory Solutions (Taufkirchen, Germany), an Airbus subsidiary

60



Virtual repair data at the repair site

Developmental AR tablet shows technician the actual repair site captured by the tablet's camera, along with information about the nature of the damage as well as repair instructions.

Source: InFactory Solutions

created in 2016 to develop digital composites production solutions for Industry 4.0. In early 2017, Airbus qualified an InFactory sensor system for inline inspection on MTorres (Torres de Elorz, Navarra, Spain) automated fiber placement (AFP) equipment (see Learn More, p. 62). InFactory Solutions managing director Franz Engel indicated at the time that laser projection was being used to pinpoint the location of defects the sensors detected, but the company's plan was to advance that application from laser projection to AR technology.

Heading up InFactory Solutions' AR efforts, Dominik Karl, Technology and Project Leader Visualization-Augmented Reality, reports that many AFP systems currently have no visualization method, and workers must find defects with only their eyes. The company has now advanced its AR visualization technology to demonstrators in a laboratory environment (TRL 4), and they expect to test the tools in factory environments during the coming year. Additionally, in May 2018 the company commercially implemented a non-AR intermediate technology, a mobile display tablet, in an AFP production setting. The mobile display provides the operator with a visualization of the defect, along with information about the defect type, position and dimensions. "But it does not include visualization at the real part's surface, and it offers limited support of localization and orientation," Karl explains, distinguishing this technology from AR.

InFactory Solutions is developing AR technology for two devices: an AR-capable version of a mobile display tablet, as well as AR glasses. As with laser projection and

the non-AR tablet, the AR devices do not conduct inspections or perform data analytics. The company's inline sensors still collect inspection data, which are analyzed via computer algorithms in the server. The server then feeds needed information to the AR device wirelessly.

The company houses its AR demonstration tools in its VisinBox AR laboratory and showroom. VisinBox technology currently focuses on two applications: VisinPro for manufacturing



production, and VisinMaint for maintenance, repair and overhaul (MRO). "Future efforts will apply AR to assembly operations as well as training," Karl adds.

The AR tablet builds on non-AR tablet technology. In addition to defect type, position and dimensions, the AR tablet is capable of guiding the operator to the defect position and then displaying production data and repair instructions on the real part surface at the defect position.

"Making virtual data available directly at the place of origin on the part surface" is the primary benefit of AR, says Karl. Compared to manual inspection and repair, inline inspection combined with AR-assisted rework and repair is expected to cut inspection time by 95%, rework time by 73% and total production time by 48%. Karl anticipates implementation of AR tablets in a production environment toward the end of this year.

Of course, the AR tablet is not a hands-free technology. This is where AR glasses come in. VisinBox AR glasses — currently, Microsoft HoloLens — display virtual data directly into an operator's three-dimensional work space. (Karl mentions that the company regularly evaluates other AR glasses as it considers different customer needs.) Looking through the glasses in VisinPro, the worker sees the defect location, production data, such as the course and sequence of the defect, the nature of the defect (splice, twist, fuzzball, etc.), followed by repair instructions, repair status and the like. VisinMaint also displays vital information about

structures and parts near the repair site. For example, an operator might be made visually aware of critical electronic components situated directly behind a delamination that is to be repaired.

One key technology aspect of AR applications is the correct overlay of virtual and production visual elements: The technology must be able to determine and track the position of the AR tablet or glasses relative to the part surface. To create and maintain this "common coordinate system," the VisinBox tablet uses its onboard camera to detect an optical marker positioned on the part surface. A set of AR glasses uses infrared and camera sensors to determine its position within the work cell, and the server coordinates this information with the known positions of tooling, part surfaces and so on. "In the future," Karl says, "the AR device's position may be determined relative to a feature of the component." This advancement would give the operator additional freedom of movement.

The application of AR devices to manufacturing operations demands software development specific to the application. Software development is required to track the device's position, communicate manufacturing and inspection data to the device, enable the device to produce the visualization images, and enable the operator to interact with the visualized data (e.g., advance from one defect to the next). Furthermore, both hardware and software must be adapted to the particular production environment, compensating for surface reflection, lighting and other conditions. In Factory and others are hard at work on such programming, as

are some AR device providers.

In the future, Karl envisions AR applications beyond part production to other aircraft manufacturing environments. For example, in aircraft painting, a physical stencil is typically used, and correctly positioning a stencil is a tedious and time-consuming operation. Karl believes that AR technology could easily assist stencil placement, and also assist quality workers in identifying targeted areas of the paintwork requiring touch-up.



LEARN MORE

Read this article online | short.compositesworld.com/VR/AR

Read online about Applied Composite Engineering's use of PlyMatch to guide manufacture of a heated inlet for a helicopter anti-cing system | short.compositesworld.com/camera_ply, short.compositesworld.com/LaserMORE

Read more online about the Airbusqualified InFactory sensor system for inline inspection on MTorres AFP equipment | short.compositesworld.com/afp_sensor

Read more online about implementation of SART at Spirit AeroSystems facilities | short. compositesworld.com/airbus_AR

62

Expediting assembly inspection

InFactory Solutions is not the only Airbus subsidiary involved in AR solutions for composites-related manufacturing. Testia (Toulousse, France), which specializes in inspection and quality-control solutions, is marketing Airbus' Mixed Augmented Reality (MiRA) solution under the name Smart Augmented Reality Tool (SART). SART has been implemented at two Spirit AeroSystems (Wichita, KS, US) facilities where components for the Airbus A350 XWB commercial aircraft are produced (see Learn More).

Airbus Group Innovation (Suresnes, France) developed MiRA technology to reduce the inspection time for tens of thousands of brackets that hold hydraulic pipes and wire bundles in place and attach them to the composite fuselage sections of the latest production aircraft. Using a tablet-based interface equipped with a camera for visual inspection, workers access the 3D model of the aircraft and compare the built and installed assemblies to their digital designs to inspect for missing, wrongly positioned or damaged brackets. At the end of the inspection, a report is automatically generated that includes details of any nonconforming parts that can be replaced or repaired quickly.

In the first internal deployment of MiRA, in 2011, the system reportedly dropped inspection time for the 60,000-80,000 brackets in an A380 fuselage from three weeks to three days. Now, under the SART moniker, Testia has deployed the system to composite bracket manufacturer Daher Socata (Tarbes, France) on all of its

large fuselage element assembly lines for a major French manufacturer of business aircraft, and at the Spirit AeroSystems A350 fuselage manufacturing facility in Kinston, NC, US, and Saint-Nazaire, France.

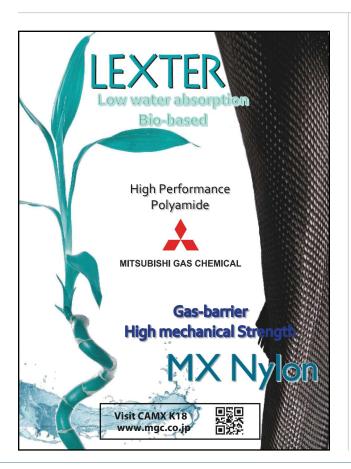
Virtually ready

With the exception only of the Virtalis installation at Airbus' Broughton facility, each VR and AR application covered here has followed successful implementation with rapid return on investment. These 3D visualization capabilities are providing composites engineers greater confidence that composites can be built and assembled *as designed*. This confidence is but one major benefit among many, not the least, the savings in time and material costs, the increase in part optimization, and other benefits already achieved by VR/AR technologies. Further, the data generated by VR/AR applications are expected to feed Deep Learning and other Smart Factory operations, taking the composites industry to even greater productivity and quality watersheds. cw



ABOUT THE AUTHOR

CW contributing writer Karen Mason returns to the CW fold after a long hiatus. She has been researching and writing about composites technology for more than 25 years. kmason@compositesworld.com





Thermoplastic composites: Scenic view



First use of thermoplastic composite guide rails to replace aluminum brings many benefits to fixed-glass, roller-blind sunroof modules.

By Peggy Malnati / Contributing Writer

>> A team in France led by Webasto SC in Les Châtelliers-Chateaumur has developed a novel fixed-glass, roller-blind sunroof module that, for the first time, uses thermoplastic composite guide rails to replace conventional aluminum rails. First commercialized on several multi-purpose vehicles (MPVs) produced by Groupe Renault (Boulogne-Billancourt), the change saves weight, cost and tooling, eliminates hardware and multiple processing steps, simplifies assembly-line installation, reduces operating noise and frees up 13 mm of additional headroom between vehicle occupants and the sunroof's glass panel.

Common in Europe but uncommon in North America, rollerblind sunroof modules are typically used to cover fixed-glass roof systems — often large panoramic roofs that span nearly the entire width and length of the vehicle's roofline. When deployed, they have much the same function as rigid sunshades do on North American vehicles, blocking excess sunlight and damping noise from rain and wind. They are comprised of a thin but light-blocking fabric that unrolls and deploys along a motorized track, and then is rolled up again around a spindle that is housed under the headliner at the rear of the roof on the vehicle interior.

Conventional sunroof assembly

The auto industry has historically used aluminum rails to connect

Change to composite guide rails simplifies production

A team in France has developed a novel fixed-glass, roller-blind sunroof module that uses thermoplastic composite guide rails for the first time to replace conventional aluminum rails. Already in production for two years on the Renault *Scenic* and *Grand Scenic* multi-purpose vehicles, this change in rail material saved weight, cost and tooling, eliminated hardware and multiple processing steps, simplified assembly line installation, reduced operating noise, and also freed up 13 mm of headroom between vehicle occupants and the glass panel.

Source | Renault SAS & Patrick CurtetProdigious

a sunroof's roller blind module to the body-in-white (BIW) roof structure, especially in the case of large and transparent, fixed-glass sunroof systems, which typically span nearly the entire length and width of the car's roof. These guide rails, mounted along the driver and passenger sides of the roof, do double-duty on roller-blind sunroof systems because they form the sliding surface along which the motorized fabric roller blind travels as the shade is rolled up to permit more light into the vehicle interior, or as it is deployed to reduce that light. Unlike the rigid sunshades common in North America, when retracted the rollerblind sunshades take up little space under headliners where they cannot be seen by vehicle occupants, yet still provide the same

64 OCTOBER 2018

thermal isolation from the sun and sound isolation from the wind and rain that rigid sunshades do.

The conventional manufacturing process for aluminum rails begins with a constant cross-section aluminum profile and requires a labor-intensive, multi-step mill-and-finish process to achieve the rail's complex shape:

- · cutting to length,
- · forming small folds via stamping and punching,
- · shaping curves,
- machining/milling complex shapes that cannot be preformed via stamping tools (requires one toolset/ operation and one quality-control check after each step),
- · anodizing rail in black or natural color,
- and assembling electrical cable clips, spiral cable clips, centering/positioning pins and nuts.

Every passenger vehicle make and model uses a slightly different shape and length rail, so sunroof manufacturers must produce and stock significant inventory during the production run of a given sunroof module. And when a new model is added, all-new tooling is required unless the vehicle shares common parts with the module for an existing model's sunroof system.

Aluminum guide rails are not only labor intensive in production at the sunroof manufacturer, but also during installation at the vehicle assembly plant. Conventionally, rails are manually fastened via screws to the BIW. Then the sunroof module is passed through the windshield bay and bottom-loaded into the opening in the roof where the operator secures it to the recently installed rails. Lastly, the glass roof itself is bonded, via structural adhesive, to the top of the car, sealing the sunroof module and the cabin interior.

Although aluminum rails represent known, established technology, they have disadvantages. For one, aluminum is a costly raw material and is more challenging than steel to bend into complex shapes. For another, to protect the environment, disposal of the anodizing chemicals used to prevent corrosion is a significant additional cost. As detailed above, the manufacturing process is long and complicated and its tooling costs are high. Also, efforts to increase functionality require the use of additional hardware applied via additional assembly steps.

New rail concept

Based on other successful conversions of sunroof frames from aluminum to composites on much smaller-format moving-glass sunroof systems, a team at Webasto decided to conduct a study to see if the much-larger side rails on roller-blind sunroof systems also could be converted to composite. (Front and rear cross-beams had already been converted to composite — typically glass-reinforced polypropylene (GR-PP) — on such systems.) The goal was to add functionality, reduce manufacturing steps, part count, cost and part weight, yet still meet OEM performance requirements.

The team began by studying guide-rail functionality and operating conditions and identified the most critical feature of rails as their ability to facilitate smooth movement of the motorized sunshade with the same force front-to-back and left-to-right along the track's path. To achieve that, rails require precise geometry and a constant cross-section along their entire length, which can be greater than a meter. Additionally, the rails have to be sufficiently structural to provide a secure connection to other sunroof/module components, including front and rear sunroof cross-beams and the roof structure itself, the motor mechanism, roof glass and the headliner. To meet OEM requirements, the motorized sunshade has to operate at low sliding-noise levels to reduce noise/vibration/harshness (NVH) in the cabin interior.

A scan of commonly used automotive composites quickly eliminated those with thermoset matrices and favored thermoplastics. >>

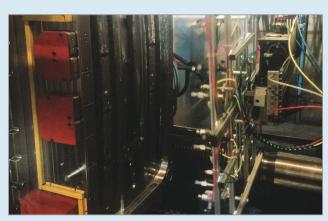




■ More space, same protection from sun and sound

When retracted, the roller-blind sunshades take up little space under headliners and cannot be seen by vehicle occupants (bottom) yet they still provide the same thermal isolation from the sun and sound isolation from the wind and rain as rigid sunshades. When paired with large transparent, fixed-glass sunroof systems like those offered on the Renault *Scenic* and *Grand Scenic* (top), they provide a large daylight opening that spans nearly the length and width of each vehicle's roofline.

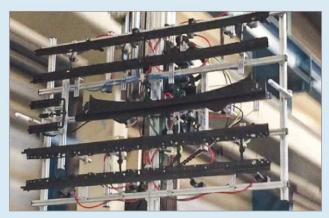
Source | Renault SAS & Patrick Curtet/Prodigious (top); Renault SAS & Anthony Bernier/Prodigious (bottom)



1 Cavity side of family tool where all eight pieces of GR-SMA/ABS composite parts are molded at each molding cycle. To mold this large family tool, a press with 1,500 KN clamping force is needed.

Source (all step photos) | Webasto SC





2 Robot removing all eight GR-SMA/ABS composite parts from the tool at the end of the molding cycle.



5 Functional and aesthetic inspection of the frame and rails.



3 Final moldings of top and bottom sides of one pair of rails prior to ultrasonic welding.



6 Final preparations for roller-blind module prior to glass bonding.



After dispensing adhesive, robot prepares to bond glass to top of sunroof system.



8 Fully assembled and pretested module ready to install on vehicle. The sunroof's water seal is carried on the glass and is achieved using the PUR adhesive that joins the glass to the rest of the module.



The pre-assembled sunshade module with glass roof is positioned by robot onto the vehicle and then bonded to the vehicle roof.

Compared to thermoplastic composites, those wet out with thermosets tend to be higher in density, have slower molding cycles and require more post-mold finishing. Further, remeltable thermoplastics offer an adhesive- and fastener-free assembly option and enormously simplify end-of-life recycling. Plus, thermosets introduced concern about possible fogging and volatile-organic compound (VOC) emissions, which are tightly regulated for vehicle interiors in the European Union.

Owing to OEM requirements for extremely tight dimensional control — particularly to avoid warpage, which would impede smooth operation of the sunshade — polyamide, polypropylene (PP) and thermoplastic polyesters were eliminated. Because aluminum rails require grease for smooth sunshade operation, and because Webasto engineers weren't sure yet if lubricant would be needed on composite rails, polycarbonate was eliminated due to its poor chemical resistance and tendency to stress crack. Acrylonitrile butadiene styrene (ABS) was rejected due to the sunroof's 110°C thermal requirements.

The Webasto team had previously used fiberglass-reinforced styrene maleic anhydride/ABS (GR-SMA/ABS) for the moving-glass sunroof frame, so it focused attention on this material, which has been used in the automotive industry for decades for instrument panel substrates. GR-SMA/ABS is low-density, stiff and strong, has very low warpage and low deformation over a broad range of temperatures and humidity levels. Because it's amorphous, there's no concern with post-mold crystallization and shrinkage. Additionally, it's melt reprocessable, welds nicely and its maleic anhydride component ensures high bond strength to a variety of substrates, including the polyurethane structural adhesive used to join the glass roof to the sunroof module.

Webasto turned to its GR-SMA/ABS resin supplier Polyscope Polymers BV (Geleen, The Netherlands) to suggest grades that would work. Polyscope supplied two possibilities — 15%-GR XIRAN SGH30EB and 30%-GR XIRAN SGH60EB — which were then subjected to small-scale lab testing at Webasto. The 30%-GR grade was stiffer, but its higher E modulus was not required to ensure smooth operation of the sunscreen. Tests indicated the 15%-GR grade would meet mechanical property targets, so the team opted to use that material, not only for left- and right-side rails but also for the front cross-beam. The rear cross-beam remained in GR-PP.

The next decision was what process to use to produce the rails. Initially, profile extrusion was considered because it can produce both hollow and solid shapes, and functionally it resembles the process used to produce aluminum profiles. It's also a continuous process, fast enough to meet production requirements, yet its tooling costs are relatively low. Unfortunately, researchers were concerned that extrusion wouldn't produce smooth enough interior surfaces from fiber-reinforced resins to enable the sunshade to move smoothly and



■ Typical aluminum guide rails

The auto industry has traditionally used aluminum rails to connect a sunroof roller blind to the body-in-white roof structure, especially for large and transparent fixed-glass sunroof systems. The traditional manufacturing process for aluminum rails begins with a constant cross-section aluminum profile (left) and requires a labor-intensive, multi-step cutting, milling and finishing process to produce the rail's complex shape (far right and top). Not only are aluminum guide rails labor intensive to produce at the sunroof manufacturer, but they also are labor intensive to install at the vehicle assembly plant.

Source | Webasto SC



quietly along the track. Also, the process would limit the ability to change profile geometry across the length of the rail to incorporate more functional integration without adding hardware (such as extra pins and clips) during post-processing steps.

The other process considered was injection molding, which can produce very complex 3D structures with smooth finishes and high aesthetics quickly, precisely and with excellent repeatability and reproducibility (R&R). Additionally, it allows holes, cutouts, snapfits and even clips to be molded in, reducing secondary finishing.

For the target application, the downside is that injection molding cannot produce a hollow structure in a single step (necessitating that each rail be molded in two pieces and then joined.) Also, tooling can be costly.

The team settled on injection molding with a goal of incorporating multiple parts in a family tool to reduce tooling costs.

Concept prove-out

With the basic concept looking promising, the development team expanded to include OEM Groupe Renault and molder AARK-Shapers (La Séguinière, France). The goal was to design a composite rail system for a fixed-glass roller-blind sunroof module on the 2016 model year Renault Scenic (five-seater) and Grand Scenic (sevenseater) multipurpose vehicles (MPVs). The team decided to design each rail to include a high level of functional integration, to have mirror symmetry between rails for left and right sides and for the

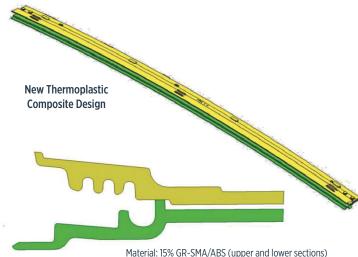


design to accommodate both standard (sedan/saloon/five-seater) and long (wagon/estate car/seven-seater) vehicle models. Aspects of the team's design are now covered by three patents.

To keep tooling costs manageable, the team optimized the mold design to allow the top and bottom parts of both left and right rails, the front cross-beam, plus three pieces of bonding interface that connect to the rear GR-PP cross-beam (molded separately) to be produced in each cycle. Another cost-saving step was AARK-Shapers' use of modular blocks (which are inserted/removed to run both long and short rail versions) rather than costly tooling slides. To mold all eight GR-SMA/ABS components in a large family tool, an injection press with a clamping force of 1,500 kN was needed. Ultrasonic welding was selected to join the top and bottom rails, and a special assembly jig was designed and built.

A prototyping and testing phase enabled the team to finalize rail design, anticipate production challenges and assure parts would pass Renault's validation tests, which included:

- •Durability testing for 10,000 lifecycles.
- •Tri-axis vibration testing over a temperature range of -20°C to 110°C at 95% relative humidity (RH).
- •Temperature cycling from 85°C to -20°C to 50°C @ 95% RH to 110°C.
- •Peel strength and shear strength after adhesive bonding.
- •Renault driving noise test for NVH.
- •Rollover "corkscrew" test.



riaconamio viete or myribo (apper ana ioner occiono)

Cross-section of composite guide rail

Final design of a composite guide rail (top) including its complex cross-section (bottom). Both top and bottom sections are injection molded in the same 15% glass-reinforced GR-SMA/ABS composite. Yellow (top) is adhesively bonded to glass; green (bottom) is ultrasonically welded to yellow top side. By injection molding each rail in two pieces for left and right sides and then ultrasonically welding each pair together, it is possible to exceed the performance and functional integration of the benchmark aluminum rails. The rails are 1,169 mm long for the Scenic and 1,239 mm long for the Grand Scenic models, nominal walls are 2-3 mm thick, and the bottom rail is 55 mm wide and the top rail is 50 mm wide.

Source | Webasto SC



WEBINARS

October 11, 2018 • 2:00 PM ET

PRESENTED BY



btglabs.com

PRESENTER



GILES DILLINGHAM Founder & CTO

Strategies to Control and Optimize Plasma Treatment in Composite Manufacturing

EVENT DESCRIPTION:

With the recent advent of practical atmospheric pressure plasma treatment systems, pretreatment of composite materials via plasma to improve the reliability of composite/composite adhesive bonds has been receiving a lot of attention. Understanding the relationship between plasma/material interactions provides material engineers with knowledge that allows science-based process control in manufacturing. This knowledge can prevent unexpected deterioration of bond quality.

PARTICIPANTS WILL LEARN:

- Plasma treatment of composite materials and the intelligent use of this technology to engineer specific, beneficial surface chemistry through plasma treatment
- · Controlling strategies for obtaining and documenting desired treatment levels
- The importance of knowledge and control of the surface state prior to treatment (age, contamination level, contaminant composition) as a major factor in variability of the outcome of plasma treatment processes.

REGISTER TODAY FOR WEBINAR AT: SHORT.COMPOSITESWORLD.COM/BTG1011





■ Mold design for composite guide rails

To keep tooling costs manageable, the team optimized the mold design to allow the top and bottom parts of both left (teal) and right (rose) composite rails, the front cross-beam (beige), plus three pieces of bonding interface (magenta, green, and lavender) that connect to the rear GR-PP cross-beam (molded separately) to be produced in each cycle. Another cost-saving step was the use of modular blocks (which are inserted/removed to run both long and short rail versions) rather than costly slides (tooling action). To mold all eight GR-SMA/ABS components in the large family tool, an injection press with a clamping force of 1,500 KN was needed. Ultrasonic welding was selected to join the top and bottom rails and a special assembly jig was designed and built. Source | Webasto SC

•Roller-blind operating speed of at least 75 mm/sec at 23°C achieved after each test.

"The idea of converting extruded aluminum guide rails to a plastic solution on a sunroof roller-blind is a Webasto idea and one that has been patented for a long time," explains Jacques Vivien, Webasto R&D, design to cost, industrial expert. "However, until recently, no engineering plastic achieved the tough requirements of this function." He reminds us that the plastic candidate had to fulfill requirements for dimensional accuracy; stability over time, resistance to temperature and humidity changes; retain stiffness and sliding capability; exhibit excellent bondability; and do all of that and remain cost-competitive. We were very pleased with the selection of Polyscope's XIRAN SGH30EB, which made the project a full success for everyone involved."

Exceeding expectations

With more than two years of manufacture and sale, the composite guide rails are performing as predicted and many benefits have been seen at the tier, OEM and customer levels. For example, ARRK-Shapers' clever tooling has cut significant costs from the program. Webasto's use of a design with significantly greater functional integration than the legacy aluminum assembly, and the choice of injection molding to create the complex structures in a single shot eliminated hardware and post-mold finishing, also



THANKS TO OUR SPONSORS

GOLD















SILVER



70

reducing cost. Rail production alone was reduced from seven steps to two.

At Renault's assembly plant, the new sunroof system, including the roller blind, arrives fully assembled and pretested as a one-piece unit that is robotically bonded to the roof, eliminating two to three assembly steps and allows an operator to be reassigned, reducing cost and time even further. Reportedly, the initial system cost reduction was around 20%, but the new module has fewer parts, which is expected to reduce warranty costs long-term as indicated by lower parts per million (PPM) defects and

+ LEARN MORE

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

higher quality seen at Renault. Another benefit from the new composite rails is that a Z-axis element-stack reduction of >13 mm

was achieved because the whole module is adhesively bonded directly to the BIW instead of the conventional two-to-three-step process, during which rails are fastened with screws to the BIW and the module is then fastened to the rails. This not only provides more working space on the assembly line for workers, but also gives taller vehicle occupants more headspace. Another subtle improvement was that NVH was reduced during sunshade

operation to open or close the huge daylight opening on both models of the vehicle. Like aluminum, the composite rails are fully recyclable, but less energy is needed to produce them initially and to recycle them at end of vehicle life, which, arguably, also makes them better for the environment. (Interestingly, the team also found that no lubricant was needed on the composite rails for reliable sunshade operation.)

"When Jacques Vivien of Webasto France first told me that he was considering replacing aluminum guide rails with SMA composite on a sunroof roller-blind module, I thought it might be a bit of a challenge, but worth taking the chance," notes Henri-Paul Benichou, Polyscope's sales and business development manager. "This innovative application proved to be a technical and industrial success, providing numerous benefits for suppliers, for Renault and for Renault's customers." cw



ABOUT THE AUTHOR

Contributing writer Peggy Malnati covers the automotive and infrastructure beats for *CW* and provides communications services for plastics- and composites-industry clients. peggy@compositesworld.com



WEBINARS

November 8, 2018 • 11:00 AM ET

PRESENTED BY

NETZSCH

netzsch.com

PRESENTER



JOHN ERNE

Dynamic-mechanical analysis—
the standard for post-process quality
assurance in composite manufacturing

EVENT DESCRIPTION:

Before assembling or delivering composite components, they will run through quality control. Due to its high sensitivity in identifying mechanical phase transitions like the glass-transition, dynamic-mechanical analysis (DMA) is the standard in post-process quality assurance. DMA can tell you if the resin cures in regions where differential scanning calorimetry struggles with the detection. This webinar will introduce the measurement principle of dynamic-mechanical analysis and show how to perform quality assurance in the composite sector.

PARTICIPANTS WILL LEARN:

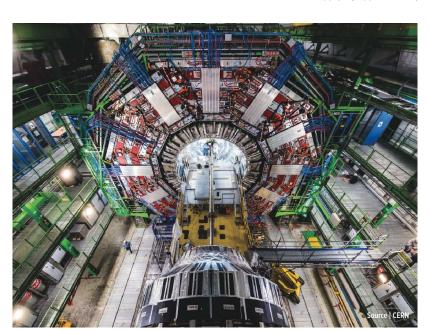
- · Measurement principle of DMA
- · What DMA can tell you about composite quality
- · How DMA fits in line with composite process control and material development

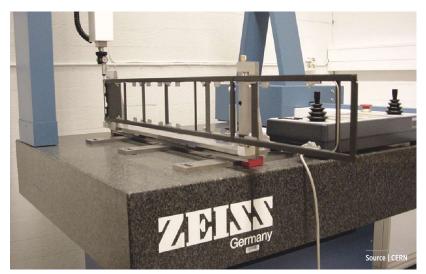
REGISTER TODAY FOR WEBINAR AT: SHORT.COMPOSITESWORLD.COM/NETZSCH11

CompositesWorld.com / 71

HIGH-PRECISION CARBON FIBER PULTRUSIONS FOR CERN

Tight-tolerance composite structures enable one of the world's leading laboratories for particle physics.





▶ CERN, the European Organization for Nuclear Research, is one of the world's leading laboratories for particle physics. Its Large Hadron Collider (LHC, Geneva, Switzerland) is the world's largest and most powerful particle accelerator and reportedly qualifies as the largest single machine in the world. It consists of a 27-km ring, within an underground tunnel, fitted with superconducting magnets along with accelerating structures to boost the energy of the sub-atomic particles. Inside the LHC, two high-energy proton beams travel at close to the speed of light, in opposite directions, before they are made to collide at four locations around its ring. LHC's Compact Muon Solenoid (CMS) detector sits at one of the four collision points and records the paths taken by particles using a silicon tracker consisting of around 75 million individual electronic sensor channels arranged in 12 concentric layers. The tracker needs to record particle paths with very high precision, yet be lightweight, to disturb the particles as little as possible.

Exel Composites (Mäntyharju, Finland) had collaborated with CERN in the past, supplying approximately 200 km of electrically insulating fiberglass composite

profiles for the LHC's electrical system. CERN turned to Exel again, to supply elements of the 688 high-precision structures that support the silicon tracker modules within the CMS detector. Very thin yet accurate carbon fiber profiles were needed, and Exel had a proven track record for producing pultrusions to tight tolerances.

Each of the 688 structures was made up of two, 1.2m-long pultruded carbon fiber/epoxy composite U-profiles of 0.7-mm wall thickness, together with L-shaped crossbars, to form a frame structure on which the particle-detecting modules would sit. To achieve the high levels of stiffness and thermal stability required, Exel designed the profiles using high-modulus unidirectional (UD) carbon fiber. A thin glass fiber surface veil was also employed to facilitate processing. All of the components and fixtures were then assembled and bonded on jigs at the Helsinki Institute of Physics to create structures with a dimensional tolerance of ±0.05 mm. The pultruded frames delivered light weight and radiation transparency, and met the extremely tight dimensional tolerances, straightness requirement and necessary mechanical properties at the low temperatures maintained in the CMS.

Exel delivered the tracker support profiles to CERN from 2001 to 2005, with the final operational use starting in 2008. The CMS detector has been performing well, culminating in 2012 with the discovery of a new elementary particle, the Higgs boson. Says Antti Onnela, CMS Tracker Project Engineer at CERN, "We had quite challenging requirements for these composite structures and earlier laminated versions did not meet them. Exel developed the needed thin-walled U-profiles that turned out to be technically superior, but also more economical thanks to the production process that minimized the wastage of expensive carbon fiber. After nine years in service in the CMS the Exel parts continue performing as flawlessly as in the beginning." cw

72

Composites Events

Oct. 1-3, 2018 - Atlanta, GA, US 2018 Polyurethanes Technical Conference

polyurethane.americanchemistry.com/2018-Polyurethanes-Technical-Conference.html

IBEX 2018

Oct. 2-4, 2018 - Tampa, FL, US

ibexshow.com/show-info/

Oct. 2-3, 2018—Scottsdale, AZ, US SpeedNews 23rd Annual Business & General **Aviation Industry Suppliers Conference**

speednews.com/business-and-general-aviationindustry-suppliers-conference

Oct. 3-4, 2018—Loughborough University, UK Composites in Sport

compositesinsport.com

Oct. 9-10, 2018-Novi, MI, US Lightweighting World Expo 2018 lightweightingworldexpo.com

Oct. 10-11, 2018-Munich, Germany Munich Technology Conference on Additive Manufacturing 2018 Oerlikon.com

Oct. 15-18, 2018-Dallas, TX, US

CW CAMX 2018

thecamx.org

Oct. 16-17, 2018—Washington, D.C., US **AWEA Offshore WINDPOWER 2018** awea.org/events

Oct. 25-27, 2018—Istanbul, Turkey **Eurasian Composites Show** eurasiancomposites.com/2018/event-brochure/

Oct. 30-31, 2018-Bremen, Germany ITHEC 2018: 4th International Conference and **Exhibition on Thermoplastic Composites 2018** ithec.de/home

Oct. 31-Nov. 1, 2018—Birmingham, UK Advanced Engineering UK 2018

Nov. 5-6, 2018—Stuttgart, Germany 4th International Composites Congress (ICC) composites-germany.org/index.php/en/ dates/4th-icc

Nov. 6-8, 2018—Stuttgart, Germany Composites Europe/Lightweight Technologies Forum

composites-europe.com

Nov. 6-8, 2018—Sao Paulo, Brazil Feiplar Composites + Feipur 2018 feiplar.com

Nov. 14-16, 2018—Seoul, Republic of Korea JEC Asia

jeccomposites.com/events/jec-asia-2018

Nov. 14-15. 2018—Vienna. Austria German Wood-Plastic Composites Conference 10times.com/wood-plastic-composites

Nov. 21-22, 2018—Marknesse, Netherlands International Symposium on Composites Manufacturing ISCM 2018 nlr.org

December 4-6, 2018—San Diego, CA, US

CW Carbon Fiber 2018 carbonfiberevent.com

Jan. 10-12, 2019-Mumbai, India **ICERP 2019** icerpshow.com

Jan. 30-Feb. 1, 2019—Tokyo, Japan TCT Japan 2019

tctjapan.jp/index en.html

Feb. 19-20, 2019—Charleston, SC, US SPE 2019 Thermoset Topical Conference -TOPCON

spethermosets.org

Feb. 26-28, 2019—Raleigh, NC, US Techtextil North America 2019 techtextil-north-america.us.messefrankfurt. com/us/en

March 6-8, 2019—Rome, Italy 5th Annual World Congress of Smart Materials: 2019 bitcongress.com

March 12-14, 2019—Paris, France JEC World 2019 jeccomposites.com

March 24-28, 2019-Nashville, TN, US **NACE Corrosion 2019** nacecorrosion.org

April 8-10, 2019-Rosemont, IL, US North American Pultrusion Conference s1.goeshow.com/acma/2017PultrusionConference/ ereg419088.cfm

April 9-11, 2019—Detroit, MI, US SAE 2019 World Congress & Exhibition 10times.com/sae-world-congress

April 23-25, 2019-Moscow, Russia Composite-Expo-2019 composite-expo.com

May 20-23, 2019—Charlotte, NC, US SAMPE 2019 Technical Conference and Exhibition nasampe.org/events/EventDetails. aspx?id=904362&group/

LEARN MORE

See more events at: short.compositesworld.com/events



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:

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: sticktoguality@generalsealants.com

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

www.teamtextiles.com sclarke@teamtextiles.com

(401) 762-1500 • Fax: (401) 762-1580



Complete ultrasonic systems integration

- ⇒Ultrasonic inspection systems for your high performance materials
- ⇒C-scan and full waveform compatible
- ⇒New construction and system upgrades
- ⇒Multi-axis gantries and immersion tanks

56 Hudson Street. Northborough, MA 01532 Wildomar, CA 92595

24305 Prielipp Rd., Ste 102

508-393-0155 | Sales@matec.com | www.matec.com

Vacuum Tables for Composites





Advanced Products Group

A leading manufacturer of 3D woven materials. 3D woven and resin film infused joints, 3D woven thermal protection systems (TPS), 3D woven and resin infused via RTM near-net-shape structures/systems such as aircraft elevator, 3D woven aircraft engine parts such as fan-blades, outlet guide vanes (OGV) and 3D woven/braided aircraft engine casings. Carbon, ceramic, quartz, phenolic and SiC fibers are used in 3D woven structures.

ISO 9001:2000 and AS9100:2001 Certified

Contact: Leon Bryn Phone: 610-845-2211 ext. 3053 West Coast: 310-277-0748 Email: leonbryn@ballyribbon.com

A O D Toobhalagu Ina

Bally Ribbon Mills 23 N. 7th Street Bally, PA 19503

Concordia COMMINGLED

Blended Continuous Filament Thermoplastic and Reinforcement **Fibers for Composites**

AS9100B CERTIFIED

Contact Anthony Ciringione at 401-828-1100 ext 115 or aciringione@concordiafibers.com

Serving All Markets and Applications!

AUTOCLAVES

New or Remanufactured



Control Systems & Service Electric, Gas & Steam, High Temp & Pressure 40+ years of world wide installations

AMERICAN AUTOCLAVE CO.

East U.S. (706) 692-4480 (253) 863-5000 www.americanautoclave.com

FOR SALE

FOR SALE

SMALL ADVANCED COMPOSITE BUSINESS

- Major Southeast City
- · Design, Prototyping, Production-Leased 4,000 sq. ft. facility
- · Laboratory and Physical Testing, **Small Autoclave**
- Unique customer list and 18 year history-Flexible Terms

Contact: Thermosettechnology@gmail.com

RECRUITMENT/HELP WANTED

www.forcomposites.com

Composites Industry Recruiting and Placement

COMPOSITES SOURCES

Phone (225) 273-4001 • Fax (225) 273-1138 P.O. Box 86185, Baton Rouge, LA 70879-6185 Email: contact@forcomposites.com

ADVERTISING INDEX

AXF Technology Inc	CGTecti
Airtech International	Composites One LLCInside Front Cover
Altair Back Cover	Design Concepts
Amamco Tool	DeWal
AOC LLC9	DIATEX S.A
Automated Dynamics	Elliott Company of Indianapolis Inc
Burnham Composite Structures 54	Engineering Technology Corporation23
CAMX 3	Fives Cincinnati

ADVERTISING INDEX

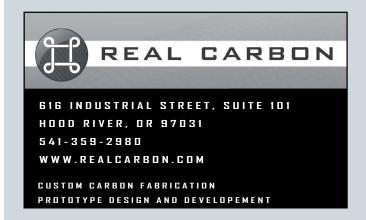
Greenerd Press & Machine Company Inc
Gurit13
Highland Composites
Ingersoll Machine Tools
Institute for Advanced Composites Manufacturing Innovation (IACMI)
Janicki Industries
Kaman Aerosystems
LEWCO, Inc
Mafic
Magnolia Advanced Materials Inc Inside Back Cover
Meggitt Polymers & Composites
Michelman Inc
Mitsubishi Gas Chemical America Inc 63
OSG USA Inc
Pacific Coast Composites
Pro-Set Inc
Revchem Composites
Roth Composite Machinery GmbH
SCIGRIP Americas61
SikaAxson US
STAUBLI Corp
Stiles Machinery
Sutherland Presses
Technical Fibre Products Ltd45
Thermwood Corporation
Tinius Olsen Testing Machine Co. Inc
Torr Technologies Inc
Weber Manufacturing Technologies Inc
Wisconsin Oven Corporation
Wyoming Test Fixtures Inc21

SHOWCASE

WESTMORELAND MECHANICAL TESTING AND RESEARCH Fast Turnaround • Reliable Results **NEW** MATERIALS **NEW** Testing SOLUTIONS REQUIRE... Quality Testing 24/7, 365 Days a Year **Shear Testing** Peel Resistance Physical Properties Compression Fatigue Testing Flexure Testing Mechanical Testing Flammability Testing Thermal Analysis: Tensile Testing DMA - DSC -TMA - TGA - DLF-1200 - Dilatometry (DIL)

For a Complete List of Composite Testing Services, Please Call 724-537-3131





CompositesWorld.com 75

Composite container protects satellites - on the ground

Bubble wrap won't work, but composites will.

By Sara Black / Senior Editor



>> Space satellites are built to painstaking specifications using specialized materials, and represent huge investments. But, before they experience the vibrations of launch and the rigors of the space environment, they first must be delivered — intact — to the launch pad. How do you ship a large space satellite that is simultaneously bulky, yet extremely fragile?

A range of satellite shipping methods exist, consisting of off-theshelf enclosures like steel shipping containers, modified modular construction trailers or very costly custom solutions. Orbital ATK, now part of Northrop Grumman (Dulles, VA, US), had considered such options for the GEOStar-3 geosynchronous satellite bus structure that it builds at its Dulles facility. But, says lead cognizant systems engineer on the project Steve Hood, the company decided that it could build a better box in-house, at a lower cost, that could be tailored with the features it needs for protection during shipment, typically on an Antonov cargo plane, to launch locations like Guiana Space Center in French Guiana.

To aid Hood's in-house engineers, Pagnotta Engineering Inc. (PEI, Exton, PA, US) was brought on board to assist in the mechanical design process. Northrop Grumman and PEI brought in industrial composites specialist Ershigs (Bellingham, WA, US), a maker

Ready for transport

A GEOStar-3 geosynchronous satellite bus structure, safely cocooned within a custom satellite container, is loaded into an Antonov cargo plane for shipment to its launch location. The container required considerable design and careful fabrication.

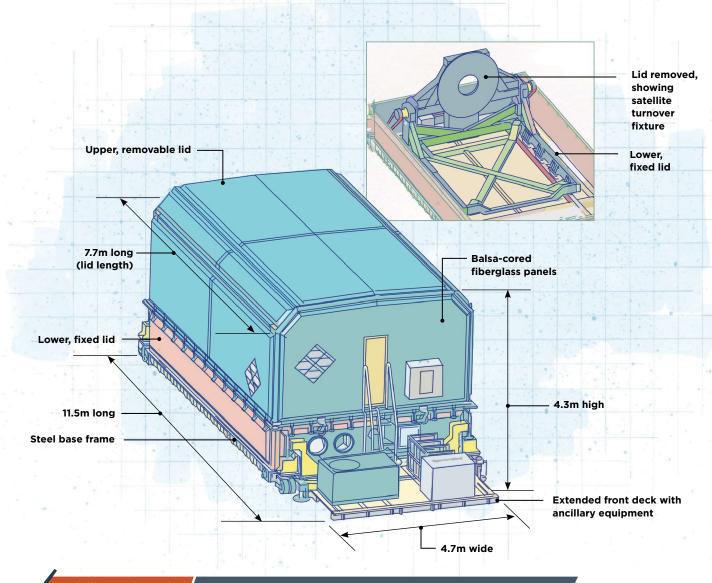
Source: | Northrop Grumman

of tanks and vessels, piping, industrial scrubbers and other largescale industrial applications, to fabricate this critical structure. "With a \$100 million satellite, you don't want any damage during shipping," says Hood, with not a little understatement.

Exacting requirements

The task was not trivial. A GEOStar-3 satellite can weigh up to 3,200 kg (depending on its mission), and has dimensions of 3.9m (max) by 2.1m by 2.3m. In addition, its shipping container had a long list of performance requirements, says PEI's vice president John Callahan. "The container had to be shippable by truck, rail or aircraft, and specifically, had to fit inside an Antonov 124-100 cargo aircraft." In addition, Northrop Grumman required that it be large enough to accommodate current as well as future spacecraft,

76



DESIGN RESULTS

Northrop Grumman "Galileo" Satellite Shipping Container

- Cored composites in container lid meet strength and stiffness design requirements with minimal joints.
- > Two-part lid (upper and lower) reduces lift height, simplifies equipment access.
- Steel base frame accommodates turnover fixture and vibration isolators for smoother transit.

Illustration / Karl Reque

and include "wire rope isolators," or devices that absorb vibrations and prevent shocks to fragile equipment while in transit.

From a handling point of view, adds Callahan, the container had to be robust enough to meet Northrop Grumman's standards for mechanical ground support equipment (e.g., forklift trucks, overhead cranes); have adequately strong lifting points; have an airtight yet removable lid with standard quick-release hardware; have adequate interior clearance to allow for unanticipated jostling of the satellite during transport; be able to accommodate an array of auxiliary equipment on an extended front deck; and finally, still be able to clear all high-bay doors at Northrop

Grumman's Integration and Test facilities.

Hood describes some of the details that had to be considered: "The satellite is rather tall, so shipping it upright wouldn't work. We needed a turnover and handling fixture inside the container." In other words, the satellite would have to be lifted by crane into the container and attached to a handling fixture, which would slowly rotate the satellite down onto its side within the container. He adds that the engineering for the turnover fixture alone was complicated, requiring a computer-controlled system for the pivot actuators. Many more operational details, such as a heat pump, air-conditioning system, nitrogen purge system, and an access

CompositesWorld.com



Constructing the frame

The steel frame under construction at Ershigs. Great care was taken to meet tight dimensional tolerances using a sequential welding plan to control heat and warpage, so that the composite lids themselves would have the correct dimensions. Source | Ershigs

door, had to be included, because the satellite has to be maintained close to room temperature during transport, and sometimes in a nitrogen atmosphere depending on the types of instruments on board.

Hood's team and PEI turned to several software tools for the container's design and composite materials selection. CAD software PTC CREO (previously known as Pro/Engineer) from PTC (Needham, MA, US) allowed solid modeling for establishing the container shape and dimensions. FEMAP finite element analysis (FEA) software from Siemens PLM (Plano, TX, US) was used for pre- and post-processing, and NX/NASTRAN software, also from Siemens PLM, was used as the solver for the FEA model. The modeling software enabled static, quasi-static and modal (natural frequency) analyses, and determination of maximum dynamic loads and stresses due to transportation loading environments,



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

enabling safety considerations in the design. The software's buckling eigenvalue solution module and classical engineering

equations helped PEI ensure that potential stress levels would be within allowable limits for the container's laminate architecture, which would consist of cored fiberglass sandwich panels. Also, dynamic displacement of the satellite and its turnover fixture were determined to ensure adequate clearance to the container's interior walls.

Building Galileo

The model results showed that a structure with overall dimensions of 11.5m long by 4.7m wide by 4.3m high, with a "lid" that was 7.7m long by 4.7m wide by 3.9m high, would meet the requirements and accommodate the GEOStar-3, with enough room for other larger spacecraft. Steel would be specified for the base

frame, with its extended front deck, to ensure compatibility with shipping logistics and to accommodate the weight and motion of the complex satellite turnover fixture, as well as provide mounting points for the vibration isolators. The lid on top of the base frame would be made with cored fiberglass, to provide an air-tight, durable and weatherproof structure with minimal joints, and good insulation value. Plus, the lid could be made on simple tooling to help minimize costs.

Ultimately, a *two-part* lid was designed, says Callahan; this was done for several reasons: "Splitting the lid into a lower and an upper section did several things. It reduced the overhead lifting distance, or height needed to clear the spacecraft, during lid removal. And, having the fixed lower lid bolted to the base frame meant that we could keep the connections to auxiliary equipment within that fixed lower part, to simplify operation." The lower lid would be 1m high, and the upper lid would be 2.8m high; the two would be fastened together with multiple quick-release toggle latches. To facilitate logistics, the upper lid was designed with casters at its lower edges, front and back, so that it could be moved easily when detached. It would also have a man-door to provide access to the interior, for preparation activities (e.g., tie-down, purging with nitrogen) prior to shipping.

Hood says, "We would have a weekly telephone conference call to monitor the progress of the design," which was dubbed *Galileo* (a more elegant name than "*Antonov* shipping container"). Once PEI completed the FEA, design model and fabrication drawings, they were turned over to Northrop Grumman, where engineers integrated the design database into their product data management (PDM) system. The design package was delivered to Ershigs engineers following Northrop Grumman review and approval.

Ershigs vice president and chief operating officer Steve Hettick says that the project was fairly rigorous, with tight tolerances: "Given the physical properties requirements and dimensional tolerances from the client, including minimum stiffness and



■ Fiberglass laminate

This photo of the lower lid, which is fixed to the steel base, shows the cored panel configuration, and the beveling of the core towards the panel edges. This provided a solid fiberglass laminate along the panel flanges for a much easier and more efficient way to join the panels. Source | Ershigs

strength, it was necessary to use resin infusion methods, rather than open molding methods typical for one of our tank products, for instance." The model called for cored panel construction over the lid's flat surfaces, with seven separate panels for the larger upper lid, and four panels for the lower lid. Northrop Grumman specified that the core would be beveled at a 45° angle towards the panel edges, or flanges, at the corners and edges, explains Hettick: "This provided a solid fiberglass laminate along the panel flanges for a much easier and more efficient way to join the panels together."

The panels were made with multi-ply skins consisting of E-glass knitted biaxial fabric (E-LTM 1208), chopped strand mat, and woven roving, supplied by Vectorply Composites (Phenix City, AL, US), Owens Corning (Toledo, OH, US) and ValuTex Reinforcements (Washington Court House, OH, US), respectively. Four plies totaling 0.125 inch thickness make up the face sheets over the core; plies are extended beyond the beveled core, and then built up with 14-17 additional plies of Vectorply Composites' biaxial glass to form the monolithic panel edge flanges, for a minimum flange thickness of 17.8 mm. The core is a 76-mm-thick BALTEK (Sins, Switzerland) SB 50 balsa wood with a density of 109 kg/m3. Hettick says balsa was chosen because it provides good stiffness without a significant weight penalty, and good insulating value. The resin is a Derakane Class 1 fire-retardant vinyl ester (510-B) from Ashland (Columbus, OH, US). Panels were vacuum infused on an airtight flat table mold and cured at room temperature.

To assemble and join the panels for the lower and upper lids, they were braced and aligned in metal holding jigs to maintain tolerances, while the panel edges were secondarily bonded



■ Bracing for tight tolerances

The tight tolerances required bracing of the upper lid panels during assembly and joining.

Source | Ershigs

together. "We wet out glass mat and woven roving to laminate the edges together," says Hettick. He adds that Ershigs built the steel base frame as well.

Truck, plane and barge

Hood says that once all of the interior fitments were ready to go, including the turnover fixture (dubbed Big Blue, because of its blue paint), fabricated by D.L. George & Sons (Waynesboro, PA, US), a load proof test was conducted using weights that totaled twice the design weight of the satellite: "We loaded it onto a truck, drove it around, and monitored its performance, and it passed with flying colors." So far, the shipping container has been used three times to successfully transport spacecraft via the *Antonov* cargo plane to French Guiana. On the most recent trip, the container was barged back to the US and then trucked to Dulles.

Concludes Hettick: "While this project was a specialty item for us, it was a fun project, as well as a challenge, because the specified tolerances were fairly tight for the size of the part." Hood adds: "We had the right team of people for this job, and we were very satisfied with the results." cw



ABOUT THE AUTHOR

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

CompositesWorld.com / 79



Additive Manufacturing focuses on the industrial applications of 3D printing technology to make functional parts.



info on the machines, materials and

methodologies being used to grow

end-use tools and components.

PRINT ONLINE EMAIL CONFERENCE

additivemanufacturing.media

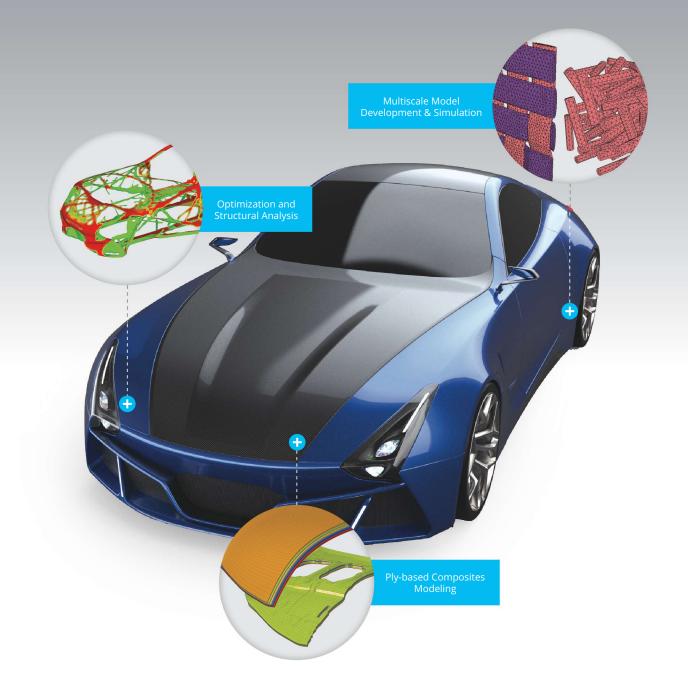


A PROPERTY OF:





www.magnolia-adv-mat.com sales@magnolia-adv-mat.com 770.451.2777 | 1.800.831.8031 4360 Northeast Expressway Atlanta, GA 30340 USA



Your Partner in Composites Design and Analysis

Altair HyperWorks[™] offers a comprehensive suite of simulation and analysis tools that can help you efficiently design composite structures, convert metal parts to composites, optimize for performance and weight reduction, and intuitively explore and evaluate different configurations.

