AUTOMOTIVE COMPOSITES CONFERENCE & EXHIBITION

Novi, MI • September 7-9, 2022

Presented by SPE Automotive and Composites Divisions

WORLD'S LEADING AUTOMOTIVE COMPOSITES FORUM

COMPOSITES ⚡ THE KEY TO EV

SUBURBAN COLLECTION SHOWPLACE

The Diamond Banquet & Conference Center at the Aurburban Collection Showplace
46100 Grand River Ave. Novi, MI 48374 USA

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WELCOME TO ACCE 2022 THE KEY TO EV

On behalf of the Society of Plastics Engineers, the organizing committee would like to wish a warm welcome to ACCE to all attendees, authors, exhibitors, students, engineers and researchers!

This year, we are back for our in-person event with a clear focus on electric transformation. With the shift of the automotive industry to battery powered vehicles, the demand for safe, lightweight, cost-efficient and sustainable materials is higher than ever and presents new opportunities. This year's conference will offer technical sessions, keynotes and a panel discussion on these opportunities, but also challenges, for composite materials in electric vehicle applications.

With travel restrictions easing and international travel picking up, we are excited to welcome our friends from all over the world and to bring our composites community back together. We encourage you to re-connect, meet and converse at the exhibits and our networking events and seize the opportunity to learn, share and network with the leading players of the composites industry.

These interactions and discussions are essential activities and core motivation for our society and for all engineers, academia and professionals of the composites industry. The goal of this event is to keep the automotive sector evolving with new technologies enabled by composites and plastics.

We wish everyone a safe and successful ACCE 2022!

Best regards,
Leo and Chris

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WEDNESDAY SEPTEMBER 7

SCHEDULE SUBJECT TO CHANGE

ALL TIMES USA EDT

EXHIBITS OPEN WEDNESDAY: 7:30-8:30 AM, 9:30 AM – 12 PM, 1 PM – 5 PM, 5:45 PM – 7 PM

For up-to-the-minute updates, access the Automotive Composites Conference & Exposition 2022 on the Whova app!

7:30–8:30 — REGISTRATION / BREAKFAST / EXHIBITS OPEN

8:30–9:00 — OPENING REMARKS AND AWARD PRESENTATIONS Including Best Paper and Scholarship Awards (Opal/Garnet/Onyx):
Leonardo Simon and Christoph Kuhn, *2022 SPE ACCE Co-Chairs*

9:00-9:30 — KEYNOTE ADDRESS (Opal/Garnet/Onyx): **Advanced Polymer Composites for Next Generation Electric and Autonomous Vehicles (EV/AV) - Challenges and Opportunities,** Dr. H. Felix Wu, *Senior Technology Manager in Vehicle Technologies Office (VTO), Office of EnergyEfficiency and Renewable Energy (EERE) at the U.S. Department of Energy (DOE)*

9:30–10:30 — EXHIBITS OPEN / COFFEE BREAK *Sponsored by* 3M Science. Applied to Life.™

OPAL/GARNET/ONYX	EMERALD/AMETHYST	PEARL	CORAL
COMPOSITES IN ELECTRIC VEHICLES	**MODELING OF COMPOSITES** *Sponsored by* HEXAGON	**BUSINESS TRENDS AND TECHNOLOGY SOLUTIONS**	
10:30–11:00			
Development and Validation of an EMI Enhanced SMC Compound for BEV Applications, Adam Halsband, *Forward Engineering North America*	Development of Forming Limit Diagrams for Dry Fabrics, Chandra Kishore Reddy, *University of Michigan - Dearborn*	High Voltage Battery Composite Enclosure Design – Beyond Lightweighting, Greg Poterala, *Solvay Materials*	
11:00–11:30			
Aluminum Coated Basalt Fibers for Automotive Composites with Integrated EMI-shielding, Robert Brull, *FibreCoat GmbH*	Towards a Virtual Process Chain for GMT as Basis for Digital Product Development, Dominik Dorr, *Univ. of Western Ontario*	New Materials for EV Applications, Tariq Syed, *SABIC*	
11:30-12:00			
Multi-material Battery Enclosures: Using Composites for Strong, Lightweight EV Structures, Evan Freeman-Gibb, *Teijin Automotive Technology*	Predicting Crystallization-Dependent Residual Stress Development in Thermoplastic Composites, Nithin Kaliyath Parambil, *Center for Composite Materials*	Westlake Epoxy – Addressing Technical Challenges in EV Motors, *Alexander Schmidt,* Westlake	

12:00–1:00 — NETWORKING LUNCHEON *Sponsored by* LOTTE CHEMICAL

COMPOSITES IN ELECTRIC VEHICLES	MODELING OF COMPOSITES *Sponsored by* HEXAGON	BUSINESS TRENDS AND TECHNOLOGY SOLUTIONS	ADDITIVE MANUFACTURING AND 3D PRINTING
1:00-1:30			
Lightweighting and Thermal Management Solutions for EV Battery Pack with Specialty Materials, Somasekhar Bobba Venkat, *SABIC*	Measurement and Simulation of In-Plane Permeability for Resin Transfer Molding Process, Anand Bora, *Moldex3D*	Ford Featherweight Overmolded Composite Seat Structure (Ford, IACMI, Dura, BASF Partners), Kipp Grumm, *BASF*	Quantitative Analysis of Internal Raster Path of Additively Manufactured Components via NDT Testing, Atik Amin, *Baylor University*
1:30–2:00			
Innovative EV Battery and Underbody Shield Designs, Roman Hillermeier, *STRUCTeam Ltd.*	Material Characterisation and Predictive Analysis of Chopped Fibre Structures, Tim Hall, *Engenuity Ltd*	Efforts Towards a More Sustainable Thermoset Composites Industry, Jonathan McKay, *INEOS Composites*	Improving Mechanical Properties of 3D Printed Short Glass Fiber Nylon Composites using Isostatic Compaction, Oleksandr Kravchenko, *Old Dominion University*
2:00–2:30			
Multi-Material Structures for Commercial Electric Vehicle Chassis Applications, Rachel Weare, *WMG*	FINALIST FOR BEST PAPER AWARD: Reconstruction of Full Fiber Orientation Distribution in Molded Composites, Mohammad Nasmus Saquib, *Old Dominion University*	Incorporation of Graphene into Technical Textile Applied in the Automotive Industry, Luana Nascimento Silva, *Ford Motor Company*	Minimizing Warpage of FDM Parts, Dustin Souza, *Hexagon*

2:30–3:30 — EXHIBITS OPEN / COFFEE BREAK / JUDGING OF STUDENT POSTERS *Sponsored by* DASSAULT SYSTEMES

COMPOSITES IN ELECTRIC VEHICLES	MODELING OF COMPOSITES *Sponsored by* HEXAGON		ADDITIVE MANUFACTURING AND 3D PRINTING
3:30–4:00			
Thermoforming of EV Battery Top Cover Using Glass-Filled Intumescent Fire Retardant Polypropylene, Dinesh Munjurulimana, *SABIC*	Modeling of Wrinkle Formation in Non-Crimp Dry Fabric during Preform Compaction, Von Clyde Jamora, *Ole Dominion Univ.*		MicroCT Evaluation of Bead Microstructure for Large Area Additive Manufacturing Polymer Composite Deposition, Neshat Sayah, *Baylor Univ.*
4:00-4:30			
Use of Graphene in Sheet Molding Compound (SMC) for Applications in Electric Vehicles, Layne Gontijo, *Ford Motor Company*	Effects of Out-of-plane Ply Wrinkles on the Pre and Post-buckling Behavior of Carbon Fiber Reinforced Composites Using Finite Element Analysis, Amir Nasirmanesh, *Baylor Univ.*		Experimental Validation of Deformation Predictions for Large Scale Additive Manufacturing. Eduardo Barocio Vaca, *Purdue University*
4:30–5:00			
FEATURED PRESENTATION: How PlastiVan is Making a Difference, Eve Vitale, *SPE Foundation*	A Review on the Constitutiuve Models Applied in ABS, PC/ABS Polymers and Graphene Nanocomposites, Lamartini Barazzutti, *Euvaldo Lodi Institute / Ford Motor Co.*		FINALIST FOR BEST PAPER AWARD: Application of Thermoset Polymer Coating to Additively Manufactured Carbon Fiber Composite Tooling, Garam Kim, *Purdue University*

5:15–5:45 — KEYNOTE ADDRESS (Opal/Garnet/Onyx): **Material Innovations in EV Battery Enclosures including UL Solutions' Battery Enclosure Material Screening (BEMS),** Daniel O'Shea, *UL Solutions Inc.*

5:45–7:00 — COCKTAIL RECEPTION *Sponsored by* Westlake Epoxy

7:00 — CONFERENCE ADJOURNS FOR THE DAY

AGENDA 2024

THURSDAY SEPTEMBER 8

SCHEDULE SUBJECT TO CHANGE

EXHIBITS OPEN THURSDAY: 7:30–8:30 AM, 9 AM – 11:30 AM, 12:30 PM – 4 PM, 5:15 PM – 6:30 PM

ALL TIMES USA EDT

7:30–8:30 — REGISTRATION / BREAKFAST / EXHIBITS OPEN

8:30–9:00 — KEYNOTE ADDRESS (Opal/Garnet/Onyx): Setting up Local HV Competencies,
Wolfgang Maluche, *VP Engineering, Engineering & Planning Center (EPC), Volkswagen Group of America*

9:00–10:00 — EXHIBITS OPEN / COFFEE BREAK / JUDGING OF STUDENT POSTERS

OPAL/GARNET/ONYX	EMERALD/AMETHYST	PEARL	CORAL
10:00–10:30			
ADVANCES IN THERMOPLASTIC COMPOSITES	SUSTAINABLE COMPOSITES Sponsored by BASF	BONDING, JOINING AND FINISHING	CARBON COMPOSITES AND REINFORCEMENTS
Properties of LWRT with Different Formulations Produced in a Wet-laid Process, **Dongjie Chen,** *Hanwha Azdel, Inc.*	Sustainable Recycled Polycarbonate (PC) Based Blend and Their Biocomposites, **Neelima Tripathi,** *University of Guelph*	AERO Sustainable Material Technology Replaces Spray Paint for Durable and Sustainable Composites, **Cameron Sterner,** *AERO Sustainable Material Technology*	Challenges of Obtaining Nanocomposites for Lightweight Electric Vehicles, **Artur Rego,** *Ford Motor Company*
10:30–11:00			
High-Rate Manufacturing of Thermoplastic Composites with Electrically Conductive Constituents, **Jessica Lavorata,** *Purdue University*	Use of Nanofibrillated Cellulose in Thermoplastic Biocomposites for Eco-responsible Auto Interiors, **Mihaela Mihai,** *National Research Council of Canada*	The Invisible Force in Composites, Enabling Lightweight with OpenAir Plasma, **Frank Petrolli,** *Plasmatreat USA Inc.*	Mesophase Pitch-based Carbon Fiber Composites for Electromagnetic Shielding and Electrostatic Dissip, **Sagar Kanhere,** *Clemson University*
11:00–11:30			
Hole Size Sensitivity in Long Discontinuous Glass Fiber Reinforced Nylon Organosheets, **Oleksandr Kravchenko,** *Old Dominion University*	Upcycling of Biomass and Food Wastes in Engineering PP-based Biocomposites for Auto-parts Uses, **Arturo Rodriguez Uribe,** *University of Guelph*	Current Perspectives on Graphene Polymer Composites as Automotive Coatings, **João Henrique Moura,** *Ford Motor Co.*	Utilizing Recycled Carbon Fiber-Based Composites for Sustainable Manufacturing, **Mitchell Rencheck,** *Oak Ridge National Laboratory*
11:30–12:30			
NETWORKING LUNCHEON Sponsored by MITSUBISHI CHEMICAL GROUP			
12:30–1:00			
ADVANCES IN THERMOPLASTIC COMPOSITES	SUSTAINABLE COMPOSITES Sponsored by BASF	ADVANCES IN THERMOSET COMPOSITES	CARBON COMPOSITES AND REINFORCEMENTS
Combined LFT-D and GMT Glass Reinforced Nylon Composite for Optimization of Part Molding & Perf., **Navraj Heer,** *Fraunhofer Innovation Platform for Composites Research at Western Univ.*	Eco-responsible Parts for Automotive Interiors Made from Nanofibrillated Cellulose and Polypropylene, **Mihaela Mihai,** *Nat'l Research Council of Canada*	Life Cycle Evaluation X-Spring, **Sigrid ter Heide,** *Westlake Epoxy*	Innovative and Sustainable Composite Lightweight Solutions for the Mobility Sector X2 Flying Car, **Timo Huber,** *HRC Group*
1:00–1:30			
Characterization of Wood Plastic Composite (WPC) by Thermal Analysis, **Yanxi Zhang,** *Netzsch Instruments North America*	Reclaimed Carbon Fibre Based Sustainable Solutions for Automotive Structures, **Somasekhar Bobba Venkat,** *SABIC*	FINALIST FOR BEST PAPER AWARD: Effect of Environmental Factors on the Properties of Resin, Interface and Composites in Automotives, **Sagar Doshi,** *Univ. of Delaware -Ctr for Composite Matls*	Preparation Methods of Graphene Textile Composites for Automotive Industry, **Denise Maria Lenz,** *Ford Motor Co., Instituto Euvaldo Lodi*
1:30–2:00			
Structural PA-6 Organosheets-based High Voltage Battery Enclosure Concept Development, **Adam Halsband,** *Forward Engineering North America*	Characteristics of Biochar Produced from Cellulose for Atmosphere CO2 Capture, **Lidia Lazzari,** *Ford Motor Company - Brazil*	Developing High Performance Pultrusion Polyurethane to Meet the High Temperature Requirements, **Elias Shakour,** *BASF Corporation*	ENABLING TECHNOLOGIES Impact from UT Uncertainty in Quantifying Ply Stack Orientation on Probabilistic Failure Envelope, **Kirtunia Rahul,** *Baylor Univ.*
2:00–3:00			
EXHIBITS OPEN / COFFEE BREAK			
3:00–3:30			
ADVANCES IN THERMOPLASTIC COMPOSITES	SUSTAINABLE COMPOSITES Sponsored by BASF	ADVANCES IN THERMOSET COMPOSITES	ENABLING TECHNOLOGIES
Doing it More Sustainable – In-situ Pultrusion of Profiles Based on PA6, **Michael Wilhelm,** *Fraunhofer Institute for Chemical Technology ICT*	Sustainability Through Sandwich Construction and New Stronger, Lighter and Greener Core Materials, **Russell Elkin,** *3A Core Materials/Baltek Inc.*	Optimization of Composite Reinforcement Througth Silane Analysis, **Gregory Treich,** *EVONIK*	Automation and Digitalization for the SMC Compression Molding Process, **Louis Kaptur,** *Dieffenbacher*
3:30–4:00			
Novel Lightweight Reinforced Thermoplastic (LWRT) for Automotive Applications, **Ruomiao Wang,** *Hanwha Azdel, Inc.*	Ocean Recycled Nylon and Lignin Biocarbon-based Sustainable Biocomposites for Auto-parts Uses, **Victoria Muir,** *University of Guelph*	An Automated Method to Measure Adhesive Thickness Between Metal/Composite Stuctures Using Ultrasound, **Daniel Pulipati,** *Baylor Univ.*	ATSP's NOWE Mold Release Coating, **Jacob Meyer,** *ATSP Innovations, Inc.*

4:00–4:30 — KEYNOTE ADDRESS (Opal/Garnet/Onyx): Opportunities for Composite Material in Future Multi-material Battery Enclosures,
Warden Schijve, *Design Leader, AZL Aachen GmbH*

4:30–5:15 — PANEL DISCUSSION (Opal/Garnet/Onyx): Plastics and Composites in Electric Vehicles,
MODERATORS: Leonardo Simon and Christoph Kuhn, *Panel to be announced*

5:15–6:30 — COCKTAIL RECEPTION

6:30 — CONFERENCE ADJOURNS FOR THE DAY

AGENDA 2022

FRIDAY SEPTEMBER 9

SCHEDULE SUBJECT TO CHANGE

ALL TIMES USA EDT

7:30–8:30 REGISTRATION / BREAKFAST

8:30–9:00 **AWARD PRESENTATIONS** (Opal/Garnet/Onyx): **Student Poster Competition and Parts Competition Award Presentations**
Uday Vaidya, *2022 ACCE Student Poster Competition Chair* **/ Teri Chouinard,** *2022 ACCE Parts Competition Chair*

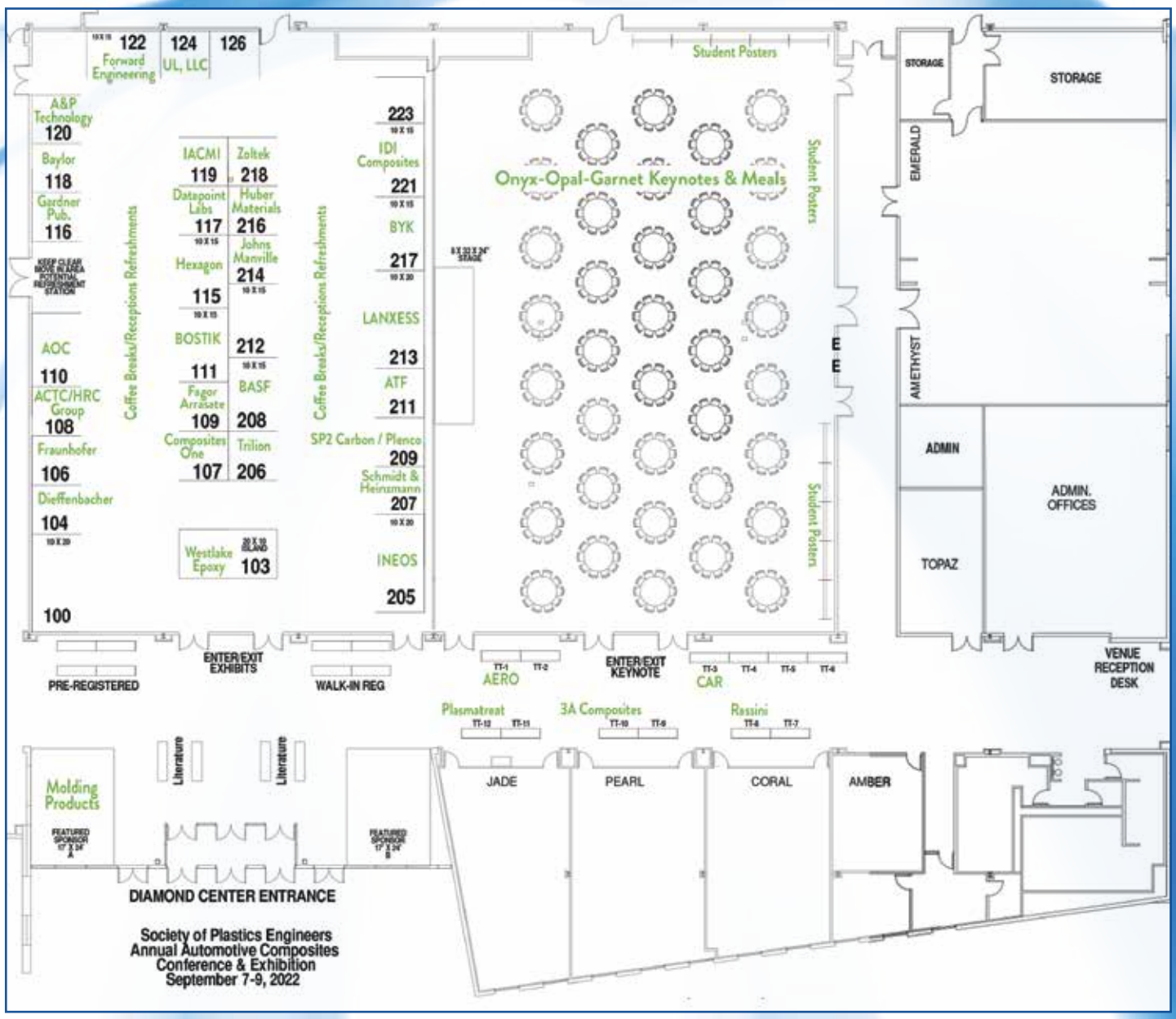
	OPAL/GARNET/ONYX	EMERALD/AMETHYST	PEARL	CORAL
	ADVANCES IN THERMOPLASTIC COMPOSITES	**SUSTAINABLE COMPOSITES** *Sponsored by* BASF	**ADVANCES IN THERMOSET COMPOSITES**	**ENABLING TECHNOLOGIES**
9:00–9:30		Sheet Molding Compound EV Battery Applications - High Performance & Sustainable Material Solution, **James Bono,** *Polynt Composites USA*	Curing Behavior of Plasmonic Spiky Gold Nanoparticles Integrated in an Epoxy System, **Cynthia Sangang Tchoconte,** *Texas Tech University*	Rapid Curing Epoxy Systems for High Throughput Production of Lightweight Composites, **Prashanth Badrinarayanan,** *Olin Corporation*
9:30–10:00	Production and Application of Electrospun Nanofibers for Poly(lactic acid) Composite Reinforcement, **J. Elliott Sanders,** *University of Maine - Advanced Structures and Composites Center*	Advanced Bio-carbon from Waste Burlap Biomass for Improved Thermal Management of Biocomposites, **Haftom Weldekidan,** *University of Guelph - Bioproducts Discovery and Development Center*	Advances in Low VOC Composite Materials for Automotive Applications, **June Wu,** *Ineos Composites*	Replacing Metal with Continuous Fiber Reinforced Thermoplastics, *Louis Kaptur,* *Diffenbacher*
10:00–10:30	ABS/PC Polymer Nanocomposites with Graphene and its Derivatives, **Silvana Pereira Rempel,** *Ford Motor Company*	Recycling Automotive PET Carpet Trimmings, **Alfonso Martinez,** *University of Waterloo*	New Advances in Molded-in-Color, UV-Stable Composites for Automotive Applications, **Jeff Klipstein,** *AOC*	HP-RTM and LCM Applications for Automotive Industry, **Gleb Meirson,** *Fraunhofer Innovation Platform*

10:45–11:15 **KEYNOTE ADDRESS** (Opal/Garnet/Onyx): **The Journey To a Composite Battery Enclosure, Dave Sullivan,**
Electrification Marketing Manager, Americas, SABIC

11:15-11:30 **CLOSING REMARKS** (Opal/Garnet/Onyx): **Leonardo Simon and Christoph Kuhn,** *2022 SPE ACCE Co-Chairs*

11:30 CONFERENCE ADJOURNS FOR THE YEAR

2022 EXHIBITOR LAYOUT



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2022 FACILITY LAYOUT

AUTOMOTIVE COMPOSITES CONFERENCE & EXHIBITION

Novi, MI • September 7-9, 2022

Presented by SPE Automotive and Composites Divisions

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2022 ACCE PART COMPETITION

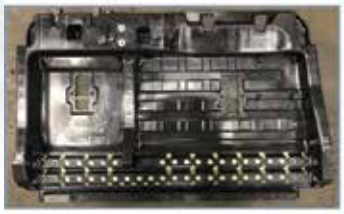
This year's ACCE Part Competition is judged by a panel of automotive composites industry experts, from industry and academia, have studied the nominations in advance of the event and will review the parts onsite. They will vote for the most innovative applications in each of 4 categories: Materials Innovation Protoype Part, Materials Innovation Production Part, Process Innovation Prototype Part, and Process Innovation Production Part. *(At press time, there were no nominations in the Process Innovation Production Part category.)*

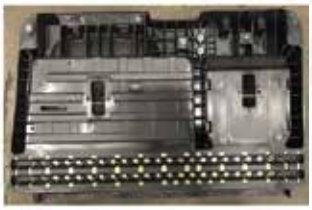
Nominations are judged on the impact and trendsetting nature of the application, including materials of construction, processing method, assembly methods, and other enabling technologies that made the application possible. Nominations emphasize the benefits of design, weight and cost reduction, functional integration, and improved performance.

A fifth prize, the People's Choice award, is selected by vote of conference attendees. Here are the nominations:

MATERIALS CATEGORY
MOST INNOVATIVE PRODUCTION PART
PU PULTRUSION OVERMOLDED SEAT STRUCTURE

Nominated by: BASF





MATERIALS CATEGORY
MOST INNOVATIVE PROTOTYPE PART
MUSTANG 14 BLUE CAM COVER WITH A LOW-COST AND RECLAIMED RECYCLED CARBON FIBER

Nominated by: University of Toronto and Ford Motor Company of Canada

PROCESS CATEGORY
MOST INNOVATIVE PROTOTYPE PART
MULTI-MATERIAL EV BATTERY ENCLOSURE

Nominated by: Teijin Automotive Technologies

PROCESS CATEGORY
MOST INNOVATIVE PROTOTYPE PART
LIGHTWEIGHT COMPOSITE AXLE SPACERS

Nominated by: Rassini International Inc.

MATERIALS CATEGORY
MOST INNOVATIVE PROTOTYPE PART
CARBON FIBER COMPOSITE TIMING COVER WITH RECYCLED CARBON FIBER

Nominated by: University of Toronto and Ford Motor Company of Canada

SPE® ANNOUNCES WINNERS OF ACCE & DR. JACKIE REHKOPF SCHOLARSHIPS

The organizing committee for the SPE Automotive Composites Conference & Exhibition (ACCE) is honoring the winners of the group's **three SPE ACCE Scholarships** and **two Dr. Jackie Rehkopf Scholarships** at this year's event. The ACCE Scholarships are sponsored by the SPE Automotive and SPE Composites Divisions. The Dr. Jackie Rehkopf Scholarships are sponsored by the SPE Automotive and Composites Divisions and the generous donations of friends and family to honor the memory of the late long-time SPE ACCE committee member, SPE Automotive Division board member, and automotive composites researcher. Both scholarship programs are administered as part of the SPE Foundation.

The ACCE scholarships ($2,000 USD each) are awarded to students pursuing advanced studies in a composites-related field. The three winners of the 2022 SPE ACCE scholarships are **Cecile Grubb,** a graduate student pursuing a PhD in Materials Science and Engineering at the University of Tennessee Knoxville, **Nityanshu Kumar,** a Polymer Physicist at The University of Akron, and **Alireza Zarei,** a PhD candidate pursuing a doctoral degree in Automotive Engineering at Clemson University.

The two winners of the 2022 Dr. Jackie Rehkopf Scholarships ($2,500 USD each) are **Sanjita Wasti,** a PhD candidate pursuing a doctoral degree in Mechanical Engineering at the University of Tennessee Knoxville and **Madhura Limaye,** a PhD candidate pursuing a doctoral degree in Mechanical Engineering at Clemson University.

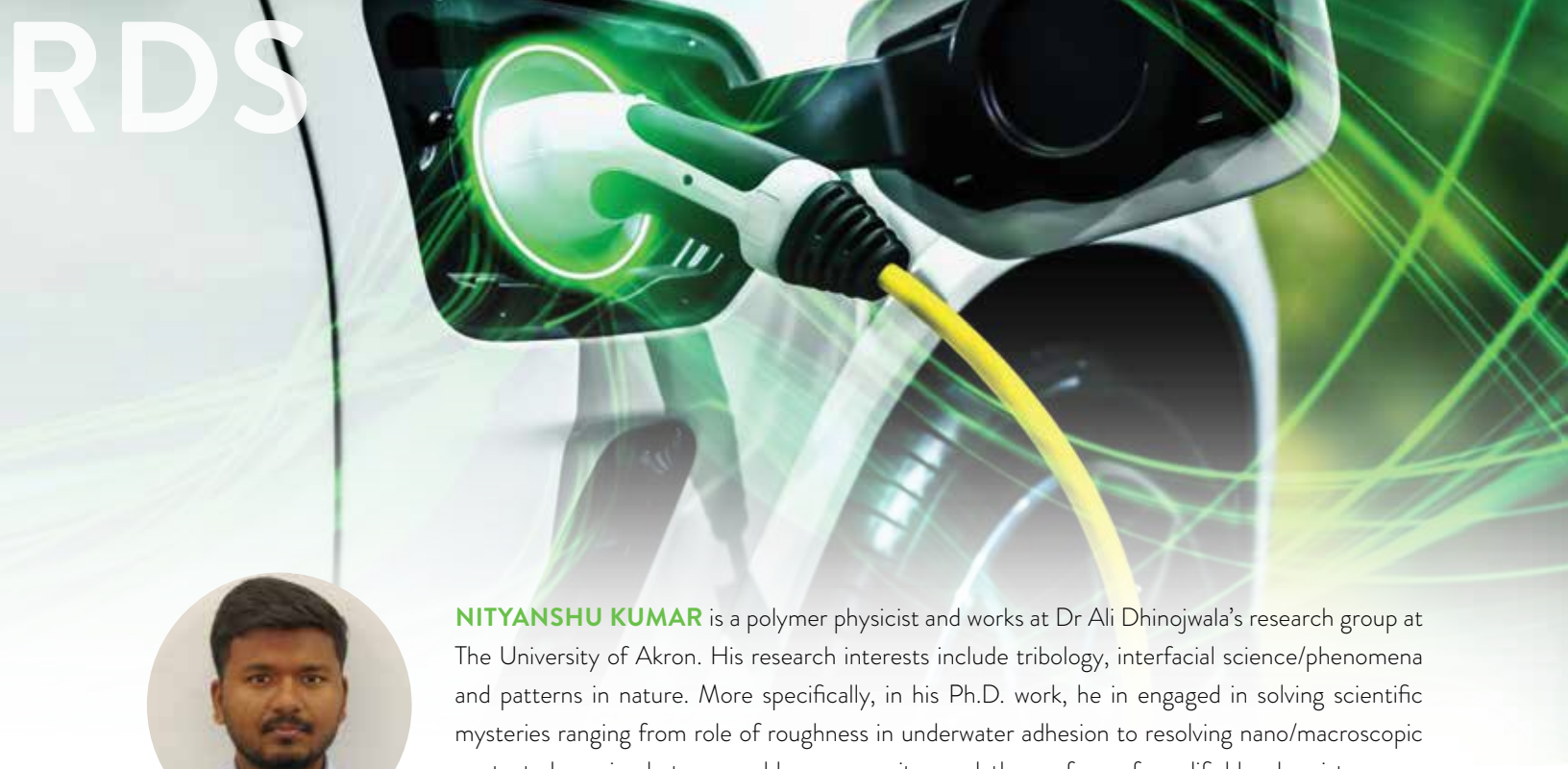
The **SPE ACCE SCHOLARSHIP COMMITTEE** was led by **Dr. Alper Kiziltas,** Amazon Advanced Materials, and included **Dr. Leonardo Simon,** University of Waterloo; **Dr. Christoph Kuhn,** Volkswagen AG; **Dr. Oleksandr G. Kravchenko,** Old Dominion University; **Dr. John W. Gillespie, Jr.,** University of Delaware; **Dr. Akshay Trivedi,** General Motors Co.; **Keith Siopes,** Sumika Polymers North America; **Andrew Geda,** Hyundai Motor Co.; and **Dr. Zeynep Iyigundogdu,** Adana Alparslan Turkes Science and Technology University.

CECILE GRUBB
2022 ACCE SCHOLAR
PhD Candidate,
Materials Science and Engineering,
University of Tennessee Knoxville

CECILE GRUBB is a graduate student at the University of Tennessee Knoxville (UTK) where she is currently pursuing a Ph.D. in Materials Science and Engineering under the advisement of Dr. David Harper. Her research is funded by Volkswagen Group of America and focuses on the development and recycling of natural fiber composites for automotive applications. Prior to her time at UTK, Cecile worked as a research associate at Western Washington University (WWU). While there, she developed custom materials for a variety of applications including aerospace interiors, satellite thermal protections systems, and recyclable thermoset composite matrices. Her long-term goal is to develop sustainable materials for advanced composite applications.

ALIREZA ZAREI
2022 ACCE SCHOLAR
PhD Candidate,
Automotive Engineering,
Clemson University

ALIREZA ZAREI joined Clemson University in 2019 as a Ph.D. student in Automotive Engineering. He has received his B.S. degree from Shiraz University in Mechanical Engineering (Solid Mechanics and Design), M.S. degree from Malek Ashtar University of Technology in Automotive Engineering, and another M.S. degree from Shiraz University in Mechanical Engineering (Applied Solid Mechanics and Design). Alireza's research focuses on designing and analyzing composites, numerical simulations, vehicle body and structure, optimization, laser ultrasonics, material characterization, and damage detection. Currently, he is working on laser-based noncontact and nondestructive techniques for the characterization and inspection of composite materials.



NITYANSHU KUMAR
2022 ACCE SCHOLAR
Polymer Physicist
at The University of Akron

NITYANSHU KUMAR is a polymer physicist and works at Dr Ali Dhinojwala's research group at The University of Akron. His research interests include tribology, interfacial science/phenomena and patterns in nature. More specifically, in his Ph.D. work, he in engaged in solving scientific mysteries ranging from role of roughness in underwater adhesion to resolving nano/macroscopic contact dynamics between rubber composites and the surface of modifiable chemistry, as a function of modulus and surface energy in a broad velocity range. Recently, he joined P&G as postdoctoral researcher to model hair friction. He continues to contribute to the field of soft tribology, automotives and composites through his work at The University of Akron. Nityanshu obtained his undergraduate degree in polymer science and technology from Indian Institute of Technology (IIT) Roorkee.

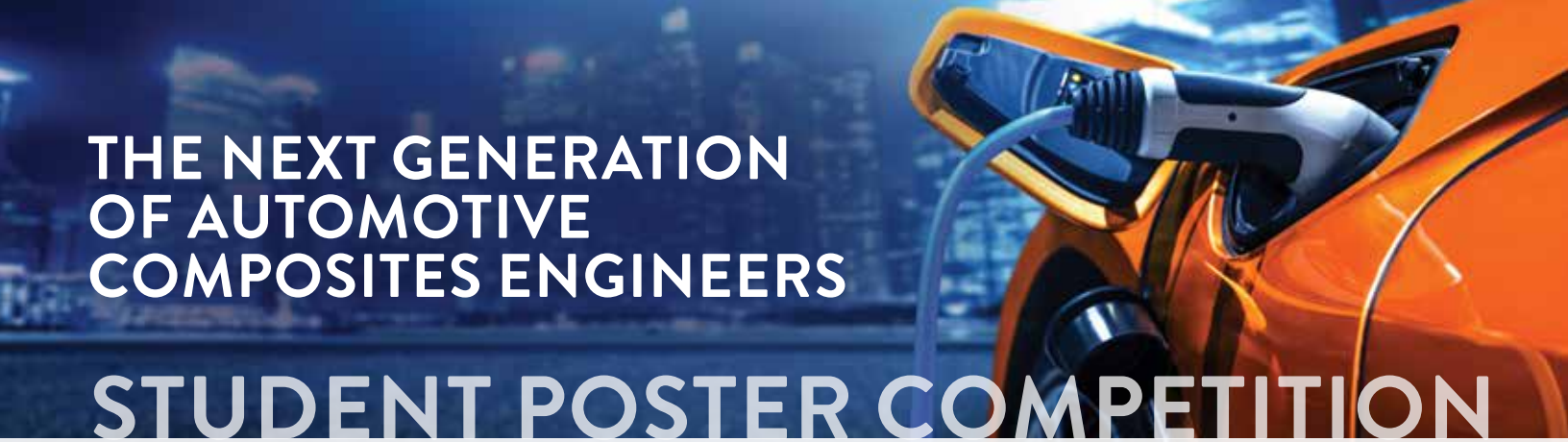
SANJITA WASTI
2022 DR. JACKIE REHKOPF SCHOLAR
PhD Candidate,
Mechanical Engineering,
University of Tennessee Knoxville

SANJITA WASTI is is currently pursuing a Ph.D. in mechanical engineering at the University of Tennessee Knoxville (UTK) under the supervision of Dr. Uday Vaidya. She holds a master's degree in biosystems engineering from Auburn University, Alabama. Her research work focuses on the processing of natural and hybrid fiber-reinforced composites, their characterization, and product development. She has been working on the non-additive manufacturing applications of bio-fibers composites task in "Innovative High-Feed Rate Additive Manufacturing Using Sustainable Nano/Microcellulose-Reinforced Thermoplastic Composites: Phase II" program which is in collaboration with Oak Ridge National Laboratory (ORNL) (Manufacturing Demonstration Facility (MDF)), UTK and the University of Maine. Furthermore, she has significantly contributed to several other ORNL, UTK, Institute for Advanced Composites Manufacturing Innovations (IACMI), and industry-funded projects and has gained a wide range of experience in different composite materials, manufacturing processes, and characterization techniques.

MADHURA LIMAYE
2022 DR. JACKIE REHKOPF SCHOLAR
PhD Candidate,
Automotive Engineering,
Clemson University

MADHURA LIMAYE is a PhD student at the Mechanical Engineering department of Clemson University. Her research work is focused on manufacturing and process simulations of fiber reinforced composites (FRPs), prediction of process effects and mechanical performance of composite structures. She has experience in design, computational modeling and optimization of heat transfer, structural and acoustic problems. She has solid background in material science, manufacturing processes and composite mechanics.

STUDENT POSTER COMPETITION SPONSORED BY



THE NEXT GENERATION OF AUTOMOTIVE COMPOSITES ENGINEERS

STUDENT POSTER COMPETITION

– SPE ACCE Attendees Encouraged to View the Student Posters in the Keynote/Lunch Area
– Student Program and Competition Judging

The student poster session is an annual event at the ACCE where students from U.S. and international universities present state-of-the art work related to plastic composite materials and manufacturing technologies relevant to automotive applications. Please join us in welcoming the students and take a look at their hard work, which will be on display in the keynote area and where lunch is served. This provides the students with an excellent opportunity to meet members of the automotive composites community and ask them what it's like to work as an engineer or scientist in this field. It also provides OEMs and their suppliers with the opportunity to meet the next generation of automotive composites engineers and scientists and potentially to hire them.

Judges made up of media, industry experts, ACCE attendees, and SPE board members review all posters digitally just prior to the conference and again with the student authors during the first day of the conference. Students of winning posters, judged to be in the Top 3 in graduate, undergraduate and high school categories, will win scholarships and will be awarded plaques. The awards presentation will take place during a formal recognition ceremony on Friday, September 9th from 8:30 to 9 am in the Keynote Area (Opal/Garnet/Onyx).

Students and their posters will be ranked according to the following criteria:

- Content (student and poster demonstrate clarity of topic, objectives and background)
- Motivation for research and technical relevance to conference theme
- Methodology and approach to problem
- Quality of proposed research results/findings
- Conclusion is supported by information presented

Since 2008, the SPE ACCE poster competition has been organized annually by Dr. Uday Vaidya, SPE Composites Division board member and education chair, as well as professor of Mechanical, Aerospace and Biomedical Engineering, University of Tennessee - Knoxville, University of Tennessee/Oak Ridge National Laboratory Governor's chair in Advanced Composites Manufacturing, and chief technology officer with the Institute for Advanced Composites Manufacturing Innovation (IACMI). He was assisted this year by Dr. David Jack, associate professor of Mechanical Engineering at Baylor University.

AUTOMOTIVE

WEBSITE REPORT

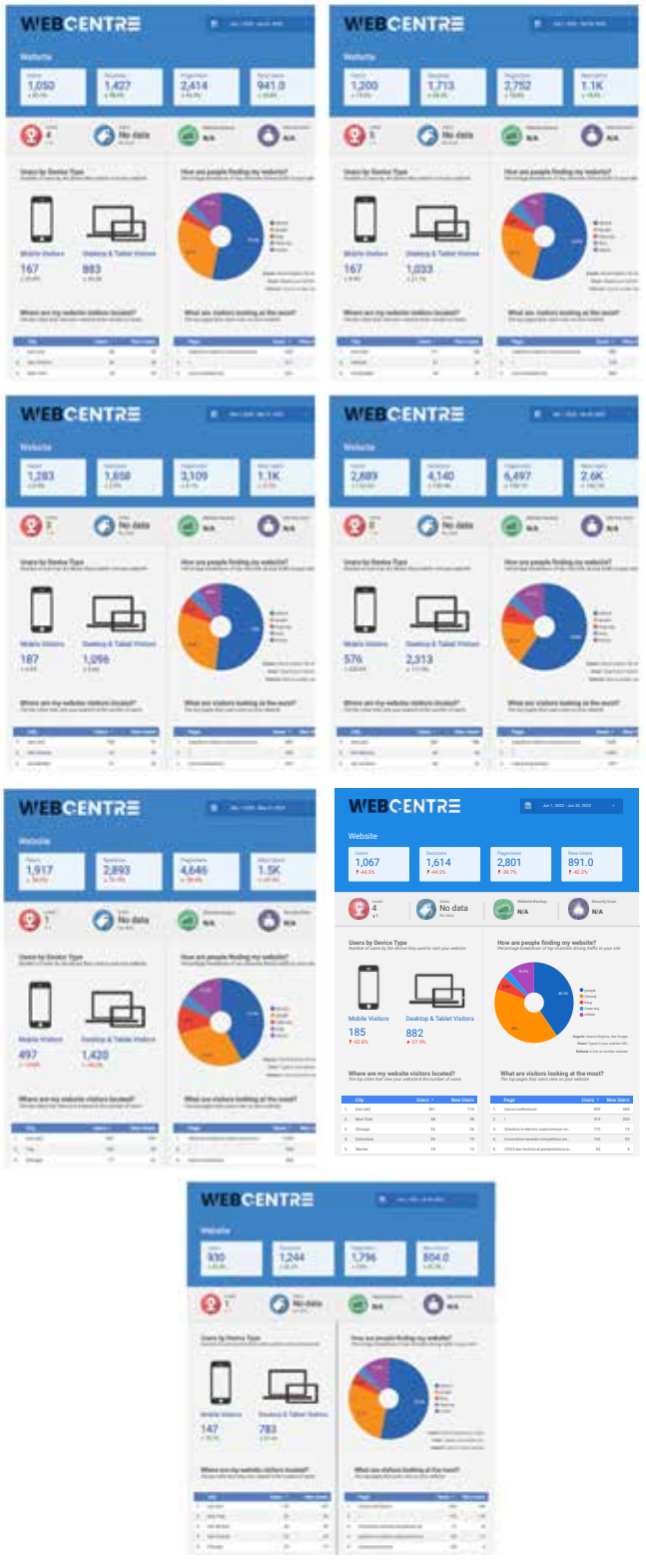
The SPE Automotive Division website **https://speautomotive.com/** is a powerhouse of information on our division and activities including conferences, events, newsletters and more. Since its debut in September 2020, it has grown to attract increasing attention in the industry making it a very valuable communications medium. Here are some key highlights:

- Website users increased each month during first quarter of 2022 – Over 1,000 users a month!
- There is increased traffic around events and conferences. April 2022 surpassed Nov. 2021 as the highest users due to EAV conference.
- ACCE is currently leading in web page views as that event nears.
- The IAG page will receive increasing views in the next few months.
- The SPE Automotive Div. website gets a bigger percentage of their traffic on desktop (rather than mobile). Which is the opposite of the world trend (most are higher percentage mobile). Why? Because people who would visit the site are likely to do it at their office/while working. (In case you were curious :)
- Supporting the SPE Automotive Div. website with sponsorship benefits the division and the Sponsor!

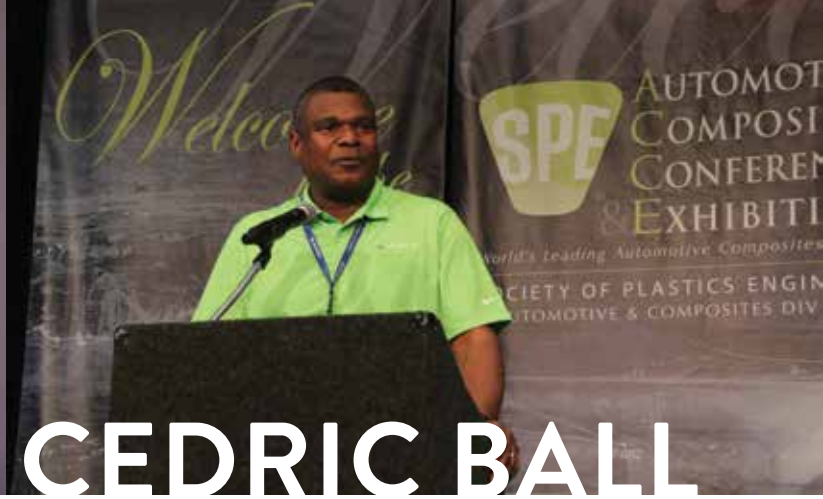
THANK YOU TO OUR WEBSITE SPONSORS:

ASCEND PERFORMANCE MATERIALS · BASF The Chemical Company · Celanese The chemistry inside innovation™ · GEON Performance Solutions · RESILIENCE · Ravago · sabic

SPE AUTO DIV. WEBSITE SPONSORSHIP IS AN AWESOME VALUE: Only $3,000 for a 2-year term is a great value for a Corporate Logo/Link on the Home Page averaging over 1,000 visitors a month interested in automotive plastics and composites! Contact **Teri@intuitgroup.com**, 248.701.8003.



2022 January thru July SPEAutomotive.com statistics



A TRIBUTE TO CEDRIC BALL

CEDRIC ANTHONY BALL – AN AUTOMOTIVE AND COMPOSITES INDUSTRY CHAMPION, LEADING VOLUNTEER AND DEAR FRIEND

With a most heavy heart we are announcing that Cedric Anthony Ball, age 59, of Powell, Ohio passed away unexpectedly Saturday, February 26, 2022, at The Ohio State University Medical Center. He was an associate of Hexion in Columbus. Born and raised in Chicago, Cedric was known for his love for his family and his kindness to friends. He was also a lover of house music, (commonly called a "House Head") and a genealogy enthusiast. He was preceded in death by his father, Anthony Ball. He is survived by his wife of 27 years, Libby J. Spaulding Ball; his children, Lisanne, Olivia and Donovan; his mother, Jean Cates Ball; and his sisters, Arlis Ball and Lorinne Ellis.

Cedric held a Bachelor of Science degree in General Engineering from the University of Illinois at Urbana-Champaign and co-MBA from Ecole des Hautes Etudes Commerciales (HEC Paris) and the Stephen M. Ross School of Business Administration at the University of Michigan - Ann Arbor. Cedric also was a certified 6 Sigma Black Belt.

Cedric established an outstanding global career as Innovation, Marketing and New Business development leader in composite materials with in-depth knowledge of the automotive, wind energy and building materials markets. He began his career with General Motors as a chassis systems release engineer on the first-generation Saturn vehicle program. Since that time, he has served in a variety of marketing and new business development roles at Owens Corning, Ashland Performance Materials, BMC Inc. and Hexion Inc.

Using his professional experience to set and deliver upon strategic plans, Cedric was the Chair of the SPE Automotive Composites Conference & Expo (ACCE) in 2009 and 2010 and led the event to recognize applications in electric vehicles and be successful after challenges in the automotive industry. Cedric also volunteered on ACCE Committees for the SPE ACCE for many years and helped it to become a leading worldwide event.

"Cedric was one of the nicest gentlemen in the business and it was always my pleasure to work with him. I will miss him and so will the industry," — Teri Chouinard, Intuit Group, Inc.

"Cedric will be always remembered for his calm demeanor. He not only worked hard but worked with heart in his projects. His ability to envision and communicate customer's unmet and unarticulated needs was second to none. He will be missed in the technical community forever by many," — Pritam Das, Toray Composite Materials America.

"It was my honor and pleasure to serve with Cedric on many SPE programs. His profes- sional and personal support was well received and appreciated. I am saddened by his loss." — Fred Deans, Honored Service Member, SPE

"I met Cedric in the late nineties when he worked for Owens Corning. We remained in touch for the following twenty-five years. Across my career in plastics, I have not met a person that exemplified the terms 'gentle- man', 'businessman' and 'complete class act' more than Cedric. His work ethic was exceeded only by his integrity. His laugh was as heartfelt as it was contagious. I will deeply miss Cedric and offer my thoughts and prayers to his family." — Len Nunnery, Plenco (Plastics Engineering Company)

Cedric Anthony Ball

Cedric Anthony Ball

Champion, Leader, Volunteer, Friend

"Cedric was one of those people who treat- ed you as a friend from the first time you met him, and every time you crossed paths, he expressed genuine concern for how you were doing, before the topic changed to the business at hand. His contributions to the growth of the composites industry, and to the success of ACCE as contributor, sponsor and conference chair, are still accumulating and yet to be fully measured. I will miss his giant persona and salient insights." — Dale Brosius, IACMI CEO & Chief Commericalization Officer

"Cedric Ball was the consummate jack-of-all-trades. His strong technical background and business-oriented mindset meant that he was able to succeed in everything to which he set his mind. Cedric was known for his positive attitude and ability to bring people together. He always knew the best spot for dinner and was full of esoteric knowledge of every spot he visited. Vocation aside, Cedric was a personal friend to everyone he met. By taking personal interest in people's lives and with his diverse experiences was able to mentor and support budding talent like myself. I will sorely miss Cedric and grieve his death." — Ian Swentek, Westlake's Epoxy Business (formerly Hexion Inc.)

"I actually met Cedric the first time face-to- face in 2011 at ACCE in Novi where he joined our team. His involvement with the ACCE organization - as well SPE Composites divi- sion - was very clear from the start and has helped to put Hexion Westlake on the map. His commitment to growing this market was strong. More importantly, he was a trusted colleague and leader in many areas over his distinguished career. We are all better from knowing and working with Cedric." — Francis Defoor, Westlake's Epoxy Business (formerly Hexion Inc.)

"We share the feeling of missing a much-valued person. Cedric's integrity, warmth and people- oriented personality made it a pleasure to work together. He will be sorely missed, and our condolences go out to his family and friends." — Sigrid ter Heide, Westlake's Epoxy Business (formerly Hexion Inc.)

2022 ABSTRACTS

ADDITIVE MANUFACTURING & 3D PRINTING

Quantitative Analysis of Internal Raster Path of Additively Manufactured Components via NDT Testing

Atik Amin
Baylor University,
Graduate Research Assistant

This paper quantifies the internal raster pattern of an additively manufactured component using high-resolution ultrasonic imaging methods. It has been shown in the literature that the final part performance is a function of the internal variations in the raster patterns for each layer, and there are not commercially viable nondestructive methods to validate the as manufactured raster orientation state. This present paper is an extension of the author's earlier works including multiple material systems and samples from both an industrial 3D printer and a commercial desktop 3D printer. These materials were selected based on their representation of a wide variety of uses in the AM field. In this work a method utilizing immersion ultrasonic testing (UT), with a 10 MHz spherically focused transducer, is presented to investigate 3D printed components manufactured with various raster orientation sequences. An in-house MATLAB script was developed to analyze the UT Data, with the objective of quantifying the internal raster pattern. Using this script, C-Scan images from each layer of each sample investigated are extracted. These extracted images are then measured through a manual approach, in which points along each individual the raster are used to quantify the orientation. Results show that the method is successful in capturing the proper orientation. Results show that the method is successful in capturing the proper orientation state for the first 10 layers.

Minimizing Warpage of FDM Parts

Dustin Souza
Hexagon, Senior Application Engineer

Polymer AM has been gaining traction in nearly all industries because of its ability to create strong and light components that replace complex manufacturing processes. It is required that the accuracy for these printed parts be reliable and consistent. In this framework, a validation project was performed on the ULTEM 9085 GC of Stratasys. Three demonstrators were selected, with the aim of capturing all the 3D printed defects that may potentially compromise the accuracy of the part. In further exploring the key sources of warpage, the two major types that are encountered using the Fused Deposition Modeling (FDM) process are the in-plane warpage, upon cooling, and the creation of a bending moment, upon new layer depositions, for which a flange demonstrator and a wedge demonstrator have been considered, respectively. Besides these two generic geometries, the solution was validated on an air duct, which represents a common application and proves the solution is reliable for real and complex parts. In this presentation, a thermo-elastic and thermo-viscoelastic material model have been calibrated. The warpage predictions on the three demonstrators, utilizing both thermo-elastic and thermo-viscoelastic material models, have been compared to 3D scans. The correlation achieved was excellent, thus validating the ability of the calibrated material cards to successfully, and accurately, predict warpage.

Improving Mechanical Properties of 3D Printed Short Glass Fiber Nylon Composites by Compaction

Oleksandr Kravchenko
Old Dominion University,
Assistant Professor

3D printed composites, based on fused filament modeling, typically suffer from poor bead-to-bead interfacial bonding and relatively high void content, limiting their mechanical properties. This work explores the effect of isostatic compaction pressure and annealing on improving the mechanical properties of 3D printed short fiber polyamide 6 composites. The 3D printed composites were compacted at different pressure levels and different temperatures. The mechanical testing was used to compare treated composites with as-printed, untreated samples. The results indicate that by selecting appropriate isostatic compaction regime, both strength and modulus in principal directions of 3D printed composites can be significantly improved. Strength was improved by over 50% and 100% in printing and transverse directions, respectively, and a twofold increase of the modulus in printing direction was found for samples compacted at 80 psi and 200C.The observed mechanical behavior was explained in terms of various parameters such as degree of compaction, crystalline structure, fiber orientation state and void content. The use of the proposed iso-static compaction to 3D printed structures will be discussed.

MicroCT Evaluation of Bead Microstructure for Large Area AM Polymer Composite Deposition

Neshat Sayah, *Baylor University,*
Graduate Research Assistant

Short carbon fiber reinforced thermoplastics produced with Large Area Additive Manufacturing (LAAM) have attracted attention due to their lightweight, improved mechanical properties, multifunctional application, and low manufacturing costs. However, the physical and mechanical properties of short carbon fiber reinforced composites remain below expectations due to the void formation and unexpected orientation of fibers within the microstructure of the bead manufactured via the LAAM system. This

study aims to investigate the effect of the 3D printing process on void distribution and volume fraction and fiber volume fraction, orientation, and fiber length within the microstructure of a single bead of short carbon fiber/acrylonitrile butadiene styrene (CF/ABS) composite. In this work, high-resolution-3D micro-computed tomography (μCT) is used to evaluate the microstructure of the fabricated bead. Preliminary results explain that fiber volume fraction, orientation, and void volume fraction have changed along the single bead's direction.

Experimental Validation of Deformation Predictions for Large Scale Additive Manufacturing

Eduardo Barocio Vaca, *Purdue University, Composites Additive Manufacturing and Simulation Consortium, Director*

Additive manufacturing has enabled the fabrication of complex geometries at the scale of multiple meters that could not be produced via traditional methods in the past. However, multiple physical phenomena develop concurrently during the printing process thereby contributing to the development of internal stresses, layer-to-layer bonding, and warpage. Expensive print failures can result from delamination or excessive warpage that may occur during or after the printing process. Hence, validated physics-based simulations are paramount to enhance confidence in Additive Manufacturing (AM) technologies and accelerate product development. Additive3D is a comprehensive physics-based simulation workflow that captures anisotropic heat transfer, viscoelasticity, shrinkage, crystallization, and fusion bonding. This presentation will show experimental validation of simulation predictions made with ADDITIVE3D and will demonstrate simulation-driven shape compensation for an autoclave tool printed in the Thermwood LSAM system.

FINALIST FOR BEST PAPER AWARD
Application of Thermoset Polymer Coating to Additively Manufactured Carbon Fiber Composite Tooling

Garam Kim
Purdue University, Assistant Professor

A thermoset polymer liquid coating reinforced with ceramic particles was applied on the surface of an additively manufactured carbon fiber-reinforced thermoplastic composite to improve its surface characteristics for composite tooling application. The tool demonstrated herein was fabricated via material extrusion additive manufacturing (MEAM) and served for the fabrication of autoclave-cured laminated composite structures. Test specimens used in this investigation were additively manufactured with Polyphenylene Sulfide (PPS) reinforced with 50% by weight of carbon fiber. Approximately 10 μm thick thermoset resin-based coating reinforced with ceramic particles was applied on the surface of flat specimens using the liquid spray coating technique and cured at an elevated temperature. Surface characteristics relevant to molds used in composite manufacturing such as surface roughness, abrasion resistance, hardness, friction, and vacuum integrity were assessed for the coated and noncoated specimens. Further, autoclave tools were fabricated and coated to study coating adhesion, part demolding characteristics, and shape change throughout multiple autoclave cycles. The result showed that the coating improved the abrasion resistance, vacuum integrity, part demolding characteristics, and lowered the surface friction coefficient. Finally, the autoclave tool used in this study neither showed degradation of the coating due to the thermal cycling nor geometrical changes of the tool shape.

ADVANCES IN THERMOPLASTIC COMPOSITES

Properties of LWRT with Different Formulations Produced in a Wet-laid Process

Dongjie Chen
Hanwha Azdel, Inc., Product Developer

Light weight reinforced thermoplastic (LWRT) is a type of polymer composites with porous structure and reinforced fiber. LWRT is widely used in automotive markets due to the advantages of light weight, good formability, high strength to weight ratio, low cost part forming process and good durability. To suit the requirements of different applications, large varieties of LWRT have been developed. One way to tune the properties of LWRT is changing the formulation of the product. In this work, we study the LWRT with three different formulations produced in a wet-laid process. 1. Hybrid glass fiber and polymeric fiber reinforced polypropylene (PP) composite with blowing agent, 2. Glass fiber only reinforced PP with blowing agent, 3. Glass fiber only reinforced PP. The mechanical properties are tested by ASTM-D790 and ASTM-D638. The difference of weight reduction as well as strength-to-weight ratio among the LWRT with different formulations is studied. It has been found that the wet-laid process has great flexibility to produce LWRT with different performance by changing the formulation. A mechanism of how the formulation affect the performance of the product produced in the wet-laid process is proposed.

High-Rate Manufacturing of Thermoplastic Composites with Electrically Conductive Constituents

Jessica Lavorata
Purdue University, Ph.D. Candidate

As polymer composites gain popularity in the automotive industry, there is an increasing demand for advanced, lightweight materials with multifunctional capabilities that can be produced at a competitive cost and rate. This paper introduces a new manufacturing method and material system, referred to as M-TOW® (multifunctional-tow) which uses a novel overbraiding technique to compact thermoplastic prepreg tape into a cylindrical rod and maintain consolidation of this rod during subsequent processing steps. In these subsequent steps, the M-TOW® is reheated, formed into complex shapes, and overmolded to become localized structural reinforcement in injection molded parts. Historically, fiber-reinforced composite parts have succeeded at exceeding the mechanical properties of their metal counterparts but have not been usable in applications that require substantial electrical conductivity. This work offers solutions for integrating electrical conductivity into hybrid molded composite structures by overbraiding highly conductive wire onto the consolidated tow. The processability and conductivity performance of different wire geometries were compared before and after the forming stage. Results conclude that the integration of conductive wires into thermoplastic preforms is a viable means of extending the functionality of lightweight, high strength composites using high-rate manufacturing methods.

ADVANCES IN THERMOPLASTIC COMPOSITES (CONTINUED)

Hole Size Sensitivity in Long Discontinuous Glass Fiber Reinforced Nylon Organosheets

Oleksandr Kravchenko
Old Dominion University, Assistant Professor

The hole size effect on the notched tensile strength of discontinuous glass fiber-polyamide 6 organosheet composite material was studied. Organosheet used in this study is a novel long discontinuous fiber-reinforced polymer composite with long glass fiber and in-situ polymerized polyamide 6 (nylon) matrix. The progressive failure modeling was used to study the notch sensitivity and to analyze the failure behavior in the organosheet. The developed progressive failure model was used to conduct Monte Carlo simulations to predict the variability of notched tensile strength. The notched tensile strength was fitted with the analytical models, which were calibrated through two approaches: (i) based on simulation and (ii) experimental results. Both approaches yielded nearly identical analytical curves, indicating the usefulness of the virtual testing using progressive failure analysis. The results show that the notched strength of organosheet with the dimeter of 2 mm was at the same level as strength of unnotched organosheet. The notch insensitivity was attributed to the increased plasticity in the matrix. The present open hole tension behavior of organosheet indicates the opportunities in designing damage tolerant, notch insensitive structures.

Combined LFT-D and GMT Glass Reinforced Nylon Composite for Optimization of Part Molding and Performance

Navraj Heer
Fraunhofer Innovation Platform for Composites Research at Western University, Research Engineer

In this study, materials were selected from long fiber thermoplastic-direct (LFT-D) and glass mat thermoplastic (GMT) classes that were comprised of Polyamide-6 (PA6) as the matrix material and glass fiber (GF) as the reinforcement. Common matrix and fiber constituents allowed for the investigation of the combination of the two materials in one part. The mechanical properties of the combination of the two materials as well as the adhesion between the two materials was studied. The results indicate that the mechanical properties of combination of the two materials lay between that of LFT-D and GMT material on their own. Thus, depending on the requirements of an application, the use of GMT material in LFT-D can be optimized (rather than LFT-D or GMT alone) for reduced cycle time, better mechanical properties, reduced cost, and reduced part warpage.

Characterization of Wood Plastic Composite (WPC) by Thermal Analysis

Yanxi Zhang
Netzsch Instruments North America, Technical Sales Support

Thermoplastics are very often applied as polymer matrix materials. Polyvinyl chloride (PVC) and polyolefins (PE and PP) are the most commonly used plastics in wood plastic composite (WPC). The most is HDPE in US, and PVC or PE followed by PP in Europe. They are used in decking, auto interior parts, siding and fencing, furniture and consumer goods. Wood filling degrees between 30% and max. 90% can be observed. The higher the wood ratio, the stiffer the material. However, if the wood content is above approx. 60 or 70%, the durability of the material is reduced due to increased fungal decay. Caused by the higher wood fraction, the wood properties such as water uptake are predominating. Properties of WPC including thermal stability, composition, gases released during decomposition, stiffness, glass transition temperature, melting behavior, thermal expansion, thermal diffusivity and thermal conductivity, are important for application and characterized by DSC, TGA, DMA, TMA/DIL, LFA and EGA. Application examples in this presentation are based on WPCs with PP as thermoplastic component.

Structural PA-6 Organosheets-based High Voltage Battery Enclosure Concept Development

Adam Halsband
Forward Engineering North America, Managing Director

New series applications of polymer composites in high voltage battery enclosures for battery electric vehicles can be seen in the market today. While composite components are contributing to significant cost, mass and performance benefits, automotive original equipment manufacturer application of holistic approaches, envisioning entire thermoplastic composite battery enclosures, presents an entirely different challenge. In this presentation, we will be sharing how a new continuous manufacturing process for PA-6 organosheets by in situ polymerization of caprolactam, along with a simulation driven design approach resulted in the development of a battery enclosure concept which highlights the enabling features and benefits of PA-6 organosheets. Comprehensive CAE analysis of major load cases considered will be presented, showing excellent structural performance under 10g load, and the ability of the enclosure to withstand side impact while controlling displacement within an engineered deformation zone, with no damage to the battery module/cells. The development of a new material card for the recently launched JM Neomera™, OS-6 Series PA 6 organosheets based on 2/2 twill woven glass fiber fabric, critical for the detailed design and development of these thermoplastic composite structures, is now available to the public and will be described for the first time.

Doing it More Sustainable - In-situ Pultrusion of Profiles Based on PA6

Michael Wilhelm
Fraunhofer Institute for Chemical Technology ICT, Research Associate and Project Manager

Pultruded profiles with a thermoplastic matrix are becoming increasingly interesting for the industry due to their special advantages such as easy recyclability and the ability to be functionalized (e.g. injection overmolding, thermoforming). The production of these thermoplastic profiles can be done several ways: "Non-reactively" produced profiles can be manufactured, for example, by melt impregnation, powder impregnation, or the processing of commingled yarns. Each of these usually brings disadvantages such as a limited fiber volume content, a high void content and, in some cases, higher costs. The "reactive" processing of the monomer μ-caprolactam which polymerizes to polyamide 6 (the so-called "in-situ pultrusion") makes it possible to achieve high fiber content, excellent mechanical properties and low raw material costs. The presentation will highlight the high potential and key advantages of the in-situ pultrusion process and provide an overview and insight into recent research results.

Novel Lightweight Reinforced Thermoplastic (LWRT) for Automotive Applications

Ruomiao Wang
Hanwha Azdel, Inc.,
Senior Manager of Product Development

Reducing the overall weight of thermoplastic parts while maintaining mechanical properties has been a focus in the automotive industry over the past decades to improve fuel efficiency and lower CO_2 emissions. LWRT is widely used in automotive applications, including headliners, underbody shields, trunk trim, and rear window trim. A new LWRT has been developed which has an excellent strength-to-weight ratio and can be molded into complicated geometries with varying thicknesses. During the manufacturing process, to achieve better mechanical properties, a high consolidation level is applied to this novel LWRT. It is capable of maintaining the same level of mechanical properties with a significant basis weight reduction compared to a standard LWRT counterpart. In this paper, the mechanical properties (flexural peak load and stiffness) were benchmarked against a traditional LWRT. The physical properties, including basis weight and as-produced density, can be adjusted to meet different requirements.

Production and Application of Electrospun Nanofibers for Poly(lactic acid) Composite Reinforcement

J. Elliott Sanders
University of Maine - Advanced Structures and Composites Center, Postdoctoral Research Associate

Electrospinning is a versatile method that produces controlled fiber diameters in the form of a multi-layered mat. Since the dawn of electrospinning, polyvinyl alcohol (PVA) dissolved in water has shown high potential as an electrospinning feedstock. Today, PVA combined with cellulose nanocrystals (CNCs), show potential as a composite electrospun nano fiber (ESNF) reinforcement and can offer improved material and mechanical properties with tailored functionality. Novel approaches to ES processing include introduction of spun fibers into thermoplastics or thermosets using batch mixing or screw extrusion. These materials offer unique benefits because of their high surface area, controlled fiber dimensions, chemical and physical compatibility. This work focuses on improving sustainable material properties by production of spun PVA and PVA/CNC composite fiber mats, processing the fibers into discontinuous length, compounding the chopped fibers into a thermoplastic poly (lactic acid) (PLA), and observation of their effect on mechanical properties as reinforcement. After batch mixing and injection molding, the PLA thermoplastic matrix composite showed improved chemical compatibility when filled with a ratio of 80/20 PVA/CNC fibers as a result of the embedded CNC within the PVA fiber structure. Notable mechanical improvements included increased tensile strength, slightly reduced strain to break and increased impact resistance of PLA.

ABS/PC Polymer Nanocomposites with Graphene and its Derivatives

Silvana Pereira Rempel
Ford Motor Company, Research

Advanced graphene-based polymeric nanocomposite materials currently have great potential for application in the automotive sector. Nanocomposites have certain advantages, such as a low amount of filler material can significantly improve properties with less increase in density of the composite material. Furthermore, the size of the filler material greatly affects the properties of the composite, due to the interaction with the matrix; binding and dispersion depend on the size of the filler particle. Nanofillers have a higher surface to volume ratio and exhibit excellent intermolecular bonds and/or hydrogen bonds with the polymer matrix. In this context, graphene and its derivatives have been used as nanofillers in various thermoplastic polymers, improving the electrical, mechanical and thermal properties of nanocomposites. Thermoplastic polymers are already widely used in automotive parts, however, the development of polymeric composites with graphene nanofillers appears as a suitable alternative to improve the performance of these components and add value to the product with other properties necessary for the development of technology in terms of advanced materials for the automotive industry. This article presents a discussion on the performance of ABS/PC polymer nanocomposites with graphene and its derivatives, especially in terms of mechanical properties and potential application in automotive components.

ADVANCES IN THERMOSET COMPOSITES

Life Cycle Evaluation X-Spring

Sigrid ter Heide
Westlake Epoxy, Global Market Development Manager Transportation

Automotive OEMs have set ambitious goals to reduce the emissions of vehicles in the use phase. The implementation of lightweight components contributes to this target but the focus is shifting to the materials supply, production and recycling. The presentation discusses life cycle evaluation results of a passenger car's composite leaf spring. The study continues with a special focus on different recycling routes in comparison with the current state of the art in end-of-life treatment. Finally, the impact of a biobased raw material in the manufacture of epoxy resin is considered.

FINALIST FOR BEST PAPER AWARD

Effect of Environmental Factors on the Properties of Resin, Interface and Composites in Automotives

Sagar Doshi
University of Delaware - Center for Composite Materials, Associate Scientist

Composites are used increasingly for automotive applications and are subjected to a wide range of environmental conditions, from extreme cold and hot temperatures to high humidity. The environmental conditions influence the structural and impact resistance properties. In this research, we characterize the resin (SC-15 epoxy) properties using compression tests at quasistatic and high strain rates, interface properties (SC-15-S2 glass) using a fiber pullout test, and conduct peel tests on composites at different temperatures/moisture conditions. For resin testing, key mechanical properties are evaluated at varying strain rates from 10-3 s-1 to 7*103 and temperatures ranging from -55C to 76C. The yield stress fits a modified Eyring model over the varying strain rates. For interface characterization, pullout tests are conducted at varying embedded lengths at room temperature, -55C, and 76C. The apparent IFSS varies from ~137MPa at -55C to 38MPa to 76C. For composites testing, a thermoplastic interlayer is used to reduce shear stresses due to bending and improve delamination resistance. Floating roller peel tests are conducted at temperatures from -55C to 76C to evaluate the peel strength. The failure mode at the different temperatures is distinct, and a drastic reduction in peel strength is observed at extreme temperatures compared to room temperature. The failure modes and bonding mechanisms between the resin and the interlayer which affect the peel strength will be discussed.

Developing High Performance Pultrusion Polyurethane to Meet the High Temperature Requirements

Elias Shakour
BASF Corporation, Technology Leader-Composite Technologies

Polyurethane pultrusion is a continuous process intended to manufacture straight profiles with a constant cross section geometry. In this process, dry fibers or matts are pulled into an injection box to be impregnated with polyurethane, then the impregnated fibers or matts are pulled to a continuous die that have several heating zones to enhance the chemical reaction and the curing process. The outcome of this process is a continuous part that contains more than 70% fiber contents. The main advantage of a polyurethane pultruded part is in its unique characteristics of high strength and low-density compared to metals. This study will introduce a new developed formulation of polyurethane that withstands elevated temperatures for e-coating process or near the exhaust applications. This polyurethane has the highest glass transition temperatures (Tg) over 200C available in the market. This study will also include the process technology and its setup, comparison with other basic polyurethane systems, then show case its mechanical properties under several temperatures such as -40C, room temperature, and 80C in the coupon level and the part level. Finally, this study will present the advantages of using such high-performance polyurethane systems for automotive industry and where this technology will be applied in the automotive industry.

Optimization of Composite Reinforcement through Silane Analysis

Gregory Treich
EVONIK, Applied Technology Scientist

It is well known that glass fiber is a common reinforcing material in many types of aerospace composites, as the additional strength imparted by the glass fiber reinforcement allows for higher performance systems. Organofunctional silanes are often used to covalently bond to the glass fiber surface, thus functionalizing the surface with an organic group that further couples into a polymeric matrix. For this reason, organofunctional silane coupling agents typically offer improved adhesion, mechanical protection, hydrophobicity, and chemical resistance to glass fiber reinforced systems. In this new work, we will analyze the wetting, surface tension, and other structural properties of glass fibers treated with a unique amino silane in comparison to a commonly used amino silane in the glass fiber industry. In this talk the audience will gain an understanding of both the basics of silane coatings on glass fibers as well as some common silanes that are typically used in composites. The audience will then learn how to optimize the properties of glass fibers for their particular composite system to reach desired performance parameters. Techniques for evaluating the fiber coating, or sizing, will also be presented and can be used for a wide array of fibers from glass and carbon fiber to sustainable biofibers.

An Automated Method to Measure Adhesive Thickness Between Metal/ Composite Stuctures Using Ultrasound

Daniel Pulipati
Baylor University, Research Scientist

One of the growing needs of the automotive industry in recent years is the application of adhesively bonded joints between metals or composite materials to reduce emissions and the weight of the vehicle without compromising its structural integrity. A good and proper adhesion that is free of voids and maintains the measure of adhesive thickness is essential to avoid premature failures and obtain desired structural performance. Hence, verifying the adhesion quality is highly important to the automotive industry before such bonded parts are released. This research investigates the use of non-destructive techniques to identify and quantify the adhesive thickness between an aluminum plate and a composite laminate. Coupons with different adhesive thicknesses are fabricated by bonding metal or carbon fiber laminates. An automated algorithm that generates a 3D point cloud to measure the adhesive thickness is developed using ultrasound (UT). The results from the ultrasound technique were validated using the micro-CT (Computed Tomography), and the findings show an accuracy of approximately 0.1 mm.

Curing Behavior of Plasmonic Spiky Gold Nanoparticles Integrated in an Epoxy System

Cynthia Sangang Tchoconte
Texas Tech University, PhD Student

Novel nanocomposites are in high demand in various industries - namely automotive and aerospace sectors where they are commonly used as adhesives and coatings. They demonstrate unique physical and chemical properties, such as high strength-to-weight ratio, excellent chemical, and corrosion resistance. Noble plasmonic nanoparticles have been integrated into epoxy systems in recent years owing to their outstanding optical properties. In this paper, spiky gold nanoparticles (SAuNPs) with localized surface plasmon resonance (LSPR) of up to 1320 nm were successfully synthesized and integrated into a thermoset resin system. The subsequent curing behavior of the nanocomposite is herein reported. The SAuNPs indicated a strong characteristic peak in the near infrared (NIR) window with a high photothermal conversion efficiency of 72.9%, confirming that the plasmonic nanoparticles can effectively convert light to heat upon NIR irradiation. Non-isothermal curing kinetics of Epon 862 and Epikure Curing Agent W containing 0.1 wt% of SAuNPs were then investigated. Differential scanning calorimetry (DSC) scans of SAuNPs-epoxy systems suggest that SAuNPs facilitated the exothermic reactions of epoxy resins. Further analysis of activation energies via the Kissinger method confirmed the catalytic effect of the SAuNPs in epoxy systems. Plasmonic SAuNPs could thus potentially be a promising alternative to common photoinitiators in the NIR-assisted photopolymerization of thermosetting resins.

Advances in Low VOC Composite Materials for Automotive Applications

June Wu
INEOS Composites, Research Scientist

The paper discusses efforts in measuring and reducing volatile organic compounds (VOC) of fiberglass reinforce plastic interior automotive parts. the main source of styrene and other hazardous volatile species in a vehicle. VOCs can be measured by various methods. Reporting a VOC value without the details of the testing methods can be misleading when comparing composite materials. We review details of equipment setup and sample preparations of three VOC testing methods commonly used in the industry. A summary of pros and cons of each method in analyzing these panels is provided. To address the VOC concerns, most OEMs add a post-bake process to minimized residual volatiles in composite parts. In this paper, we discuss advanced resin technologies as alternative solutions. Several low VOC resins were formulated to reduce the VOC for specific applications or processes, without a post-baking process. Testing and odor results and odor of molded parts will be presented in cases studies. These prior learnings can be applied to future resin technology advancement in various applications, such as low VOC resins for EV battery enclosure and class A panels.

New Advances in Molded-in-Color, UV-Stable Composites for Automotive Applications

Jeff Klipstein
AOC, Technical Service Specialist

Sheet Molding Compound (SMC) technology is currently being used to mold pick-up boxes for the automotive industry. Compared to steel boxes, composites offer lighter weight solutions and flexibility in molding complex geometries; compared to aluminum boxes, composites offer better dent resistance and more robust surface aesthetics. And of course, SMC boxes are designed to meet the strength, toughness, and performance requirements the consumer demands. SMC pick-up boxes can be either painted or formulated to withstand the effects of weathering without any protective coatings. Many high-strength UV stable composites today do not offer all of the benefits (i.e., ease of compounding and molding) of other sheet molding composites. Currently, there is a new system under full evaluation that offers some of the major desired improvements. This paper describes the SMC formulation technology used to meet the physical property, weathering, and other requirements needed to produce high-quality pick-up boxes. The SMC system described in this paper uses polyester technology with conventional MgO thickening, allowing compounders to produce SMC with excellent handling characteristics at the desired material viscosity with excellent molding characteristics.

FEATURED PRESENTATION

How PlastiVan is Making a Difference

Eve Vitale,
SPE Foundation

Through positive plastics education the SPE Foundation has developed unique programs to overcome the high hurdles of successful workforce development in the plastics industry which is an invisible entity to children. Product ideation, design and manufacture is also a foreign concept to students. To impel the next generation to consider Science, Technology, Engineering, and Math (STEM) careers along the whole value chain, we must introduce the joy of science, engineering, and manufacturing early and often. In addition, under-resourced, under-represented populations in STEM need equity-building opportunities which require commitment and collaboration. To make progress, we must be willing to think big, start small and stay in it for the long haul. Eve's talk will demonstrate how to:

- Build partnerships with community-based organizations
- Develop strong key performance indicators for programming and think like an investor
- Assemble strong mentoring networks

Eve Vitale is Chief Executive at the SPE Foundation which supports the development of plastics professionals by funding quality educational programs, grants, and scholarships, emphasizing science, engineering, sustainability, and manufacturing while working to create inclusive opportunities for students around the world. She has 10+ years' experience in STEM-education and non-profit development and leads the PlastiVan®, a national plastics education program for K-12 students. PlastiVan works to change the perception of plastics one classroom at a time through positive plastics education and material sustainability while encouraging students to consider the industry they've never heard of – plastics – as a career path. Ms. Vitale has degrees in mechanical and manufacturing engineering and has worked as a consultant in recycled materials and plastics sustainability.

BONDING, JOINING & FINISHING

AERO Sustainable Material Technology Replaces Spray Paint for Durable and Sustainable Composites

Cameron Sterner
AERO Sustainable Material Technology, Innovation Team Leader

Decorating composite material for automotive applications can be difficult for OEMs and Tier 1 suppliers. Traditional spray applied paint systems are heavy, lack durability, are subject to environmental effects, and emit hazardous volatile organic compounds (VOCs) and carbon dioxide (CO_2) during application. AERO Sustainable Material Technology was originally developed as a lightweight, film-based alternative paint system for the Boeing 787 Dreamliner platform - the all-composite, ultra-lightweight commercial airliner platform. The innovative coating system was then transitioned into motorsport for optimization in the broader automotive industry, and is now deployed on all satin-finished Land Rover Defenders. The film-based decorative coating system provides aesthetic value similar to or greater than traditional paint with significantly enhanced resistance to abrasion, stone impingement, erosion, environmental effects, and also numerous chemicals and reagents. Further, the AERO system is applied at room temperature, emits no CO_2 or VOCs, and utilizes sustainable manufacturing practices to help reduce the overall environmental impact of across the entire value chain. AERO is enabling to the automotive industry by reducing capital expenditure, accelerating environmental sustainability goals, as well as greatly enhancing serviceability. The weight savings, performance, and contribution to a more environmentally friendly supply chain can provide sustainable value with composites.

The Invisible Force in Composites - Enabling Lightweight with OpenAir Plasma

Frank Petrolli, *Plasmatreat USA Inc., VP Strategic Market Development*

Talking about composites, we have to sharpen the awareness, that we need different materials, that "somehow" attract to each other. If they do, we have the great value of being able to build components that have great properties in e.g. strength, as well, and thats what we are talking about and expect, lightweight. Driving the electric (r)evolution, new composites are key, with additional and new properties to be developed. Hard on the limit of the used materials. The need to speed up developments is slowed down with broken supply chains, availability of resources in material, as well work forces. Having sustainable products also means, that we need to have sustainable production processes. To attract customers and partners and future employees. Protecting and enabling local productions. Speed up time to market and stop the over exploration of the nature for future generations. How materials can be attracted efficient and sustainable to each other will, be introduced with industrial references and examples.

Current Perspectives on Graphene Polymer Composites as Automotive Coatings

João Henrique Moura

Ford Motor Company, Technical Specialist - Research and Innovation

This short technical review prospects the recent advances of composite coatings reinforced by graphene structures for automotive applications. We summarize the advantages in the use of graphene as a coating additive, mainly focused on the protection mechanisms against corrosion and mechanical damage, the challenges, and perspectives of this innovative class of coatings.

BUSINESS TRENDS/ TECHNOLOGY SOLUTIONS

High Voltage Battery Composite Enclosure Design - Beyond Lightweighting

Greg Poterala, *Solvay Materials, Transportation Marketing Manager*

With range anxiety being a major challenge impeding consumer acceptance of battery electric vehicles, automakers are seeking solutions to improve range through a variety of means, including lightweighting, greater power density, improved operating efficiency, and others. As the battery pack contributes significantly to the weight of a BEV design must be optimized to ensure reliable, robust vehicle performance and satisfy consumers' desire for a meaningful driving experience. The enclosure of the high voltage (400 - 800 Volts) battery pack represents a significant opportunity to lightweight the vehicle. This presentation will give an overview of Solvay's collaboration with Ricardo to develop a unique thermoplastic battery design concept for a E/F segment vehicle. The aim of the project was to address the main challenges for design engineers who are identifying ways to design batteries leading to greater vehicle range. The composite design concept aimed to improve energy and power density, reduce weight and packaging space, and to contribute to greater vehicle range. Utilizing virtual engineering tools a series of design and validation loops were carried out to optimize the thermoplastic composite design, with priority towards meeting the China Crush requirement. Not only did the resultant design meet this important validation requirement it improved energy density by 23%, reduced enclosure weight by 53%, while saving space and reducing the number of parts needed.

New Materials for EV Applications

Tariq Syed, *SABIC, Staff Scientist and Product Developer*

There is increasing pressure in the automotive industry to shift towards electric vehicles (EVs). This raises the need for OEMs, tier suppliers and material suppliers to develop and bring to market new EV battery pack components, such as enclosures, modules and other structural components. These new components must combine design flexibility and functional integration, enhanced properties, with greater safety and improved economics by using alternative or new material solutions while meeting cost targets for manufacturing. Compared to conventional battery pack designs using traditional materials such as aluminum and other metals, SABIC's concept using lightweight thermoplastics can potentially realize 30 to 50 percent weight savings per component, improve energy density, simplify the assembly process, reduce costs, improve thermal control, and enhance safety and crashworthiness. The SABIC-developed battery pack concept leverages the properties and strengths of thermoplastics to improve performance, reduce cost and weight, and support mass production. This concept includes an integrated plastic-metal hybrid structure using a newly developed SABIC material for the cover and battery tray which aims to optimize thermal transfer, meet drop test requirements and absorb crash energy upon side impact that side frame members can experience.

Westlake Epoxy - Addressing Technical Challenges in EV Motors

Alexander Schmidt, *Westlake, Technical Service Manager Composites*

EV motors are increasing in rotational speed, voltage levels and combined with higher frequency semiconductor inverters. These conditions lead to a higher likelihood of rotor imbalance and partial discharges in the stator insulation. This presentation highlights product solutions to address the technical challenges and shows commercial application examples. It will also be illustrated how modelling capability helps to faster meet the customer's critical requirements.

Ford Featherweight Overmolded Composite Seat Structure (Ford, IACMI, Dura, BASF Partners)

Kipp Grumm, *BASF, Technology Leader Thermoplastic Composites*

This development covers the design, development, manufacturing and testing of the injection overmolded thermoplastic continuous fiber composite Ford Featherweight seat. This joint seating development between Ford, IACMI, Dura and BASF involves the design, development, FEA, manufacturing and testing of the composite seat structure. This unique design allows for the seat system to handle the very demanding structural loading requirements for crash testing scenarios using BASF Ultratape® continuous fiber composite overmolded with BASF Ultramid® PA6. The design process included optimizing the layup, orientation and use of the Ultratape where needed in the seat pan and seat back, placing the insert in the highest stress areas to optimize use. The inserts were then injection overmolded to complete the geometry of the seat pan and seat back, adding the benefits of injection molding for component integration, design freedom and geometrical complexity where needed in the seat. The seat performed very well in accordance to Ford's internal test methods. For example the seat structure completed 3X the required number of lives for both high cycle and low cycle fatigue In addition, CAE models were employed throughout the program to evaluate the initial design and incorporate design changes before dedicating the capital needed for the production tooling, with excellent correlation using this highly complex, dynamic FEA model.

BUSINESS TRENDS/ TECHNOLOGY SOLUTIONS (CONTINUED)

Efforts Towards a More Sustainable Thermoset Composites Industry

Jonathan McKay
INEOS Composites, Principal Scientist

The thermoset composites industry has gone to great lengths highlighting ways in which their products can potentially reduce a consumer's environmental and economic footprint. For instance, it is widely understood that the use of thermoset composites in automotive applications frequently increases fuel efficiency in the vehicle. In this presentation, INEOS Composites will illustrate advancements in creating thermoset composite resins that are themselves more sustainable, and outline plans to increase their use. Examples will include:

- The expanded use of sustainable and renewable bio-based feedstocks in unsaturated polyester resins (UPR), resulting in sheet molding compound (SMC) with reduced fossil fuel requirements
- The accelerated integration of recycled thermoplastics in UPR and low-profile additives, thereby enhancing the sustainability of the raw material supply chain
- The use of life cycle analysis (LCA) to highlight opportunities for reduced energy consumption in the production of thermoset materials
- The identification of prospects for the potential recovery, re-use, or recycling of thermoset composites

Discussion will also include the identification of current obstacles and opportunities for collaboration amongst raw material suppliers, tier-1 part suppliers, OEMs, academia, and industry consortia to create a more sustainable marketplace for thermoset composites.

Incorporation of Graphene into Technical Textile Applied in the Automotive Industry

Luana Nascimento Silva
Ford Motor Company, Researcher

This review provides a brief overview of graphene, regarding the material itself and its applications in the textile industry linked to the automotive sector. We seek to illustrate how the versatility and superlative properties of the material have the potential to inaugurate new technological platforms for these sectors of the industry, with important technological, economic and innovation impacts.

CARBON COMPOSITES AND REINFORCEMENTS

Challenges of Obtaining Nanocomposites for Lightweight Electric Vehicles

Artur Rego
Ford Motor Company

Nowadays, the global automotive industry faces challenges in critical areas, reducing the vehicles' weight being one of them. The continuous development of new materials and the exponential increase of research articles on this subject highlight alternative ways to lighten electric vehicles and their subsystems. It is noteworthy that the optimization of the engineering and iteration processes are required to maximize the vehicle's weight reduction, combining the materials' properties and the manufacturing processes to meet the final product specifications. The development of new materials, such as high-resistance steels, aluminum alloys, and polymers reinforced with carbon fiber, became important advances in the automotive industry as they present lightness, corrosion resistance, specific resistance, excellent electrical properties, and are easy to process. Polymer nanocomposites are a great ally in the present and in future automotive industry, creating new possibilities for increasing the vehicles' performance. Graphene has raised much interest recently due to its mechanical, electrical, and thermal properties. Combining it with polymeric materials makes it possible to create nanocomposites that combine the excellent properties of graphene and lightweight. The present work shows the context in which graphene nanocomposites reduce the weight of electric vehicles, showcasing their benefits and manufacturing challenges.

Mesophase Pitch-based Carbon Fiber Composites for Electromagnetic Shielding and Electrostatic Dissipation

Sagar Kanhere
Center for Advanced Fibers and Films, Clemson University, Graduate Research Assistant

Carbon fiber composites are attractive for electric vehicles because they can bring twice as much weight savings compared to glass fiber reinforced composites. The major hurdle in the adaptation of CF-reinforced composite is the cost. Mesophase pitch-based carbon fibers have a moderate performance but are potentially much cheaper than their high-strength PAN-based counterparts. Due to their highly graphitic structure, pitch-based carbon fibers are highly conducting compared to other reinforcement fibers. With the increasing digitalization of vehicles, electromagnetic radiations emitted by circuitry create electromagnetic interference and electrostatic buildup, which can lead to the failure of critical components. Hence, the material used for the vehicle body and packaging of the electronic component in the vehicle should be able to protect from catastrophic failures due to electrostatic charge buildup or electromagnetic interference. In this study, melt-

blown mesophase-based carbon fibers with the tensile strength of 2.07±0.3 GPa and electrical resistivity of 7±0.8 μΩ.m were incorporated into polyethylene. Upon addition of 30 wt% CFs, the electrical resistivity of the composite dropped by 6 orders of magnitude to 106 Ω.cm and electrostatic dissipation time reduced to 1.8 s (at 1% cut-off). Electromagnetic shielding effectiveness of the composite increased with increasing carbon fiber content; EMI SE went up from 26 dB for 3 wt% CF to 46 dB for 30 wt % CF at 1.5 GHz.

Utilizing Recycled Carbon Fiber-Based Composites for Sustainable Manufacturing

Mitchell Rencheck
Oak Ridge National Laboratory, Postdoctoral Research Associate

Carbon fiber (CF) reinforced composites (CFRPs) are one of the most widely manufactured and highest performing composite systems available to industry today. CFRPs have been commonly utilized in aerospace applications, but as the cost of CF begins to decrease other sectors are beginning to incorporate more CFRPs into their products. Specifically for the automotive industry, the main advantage of utilizing CFRPs is maintaining mechanical performance requirements while reducing the weight, which is critical to the automotive industry's effort to electrify and reduce vehicle emissions and fuel consumption. However, replacing existing metallic components with CFRPs ultimately increases material cost and the vehicle's overall price for consumers. Potential solutions for reducing the cost of CFRPs are to 1) substitute a portion of the CF content with a lower cost fiber option without significantly reducing mechanical properties and 2) utilize recycled CFRP material rather than virgin material. This work explores both solutions by examining the effect of mechanical recycling on the processability, material properties, and potential cost savings from varying the recycled content of CF hybrid composite systems through mechanical, thermal, and molecular weight characterization as well as fiber length analysis. From the changes in material properties from mechanical recycling, an understanding of how recycled CF hybrid composites to improve sustainable manufacturing can be developed.

Innovative and Sustainable Composite Lightweight Solutions for the Mobility Sector- X2 Flying Car

Timo Huber
HRC Group / Advanced Composite Technology Center, Vice President

As eVTOL became a hot topic worldwide, mobility solution providers, well established or start-ups, have all shown great interest or already dedicated themselves in the study and development of the latest generation of eVTOL product. With the model X2 flying car displayed at its booth at CIIE (China International Import Expo) 2021, HRC has officially announced its close cooperation with XPeng HT Aero, one of the most bold and leading eVOTL manufacturers in China. As the exclusive carbon fiber parts manufacturer of X2, HRC has successfully developed and delivered more than 100 types of carbon fiber parts for this futuristic flying car. To get the right material designed in the right way, the technical team defined the materials and finally shaped the seat frame and control panels with specific types of carbon fiber SMC. In addition, the parts were gloss painted to achieve a classy final finish. The HRC team was fully engaged in successfully completing the precise positioning, installation and assembly of the carbon fiber parts, including cockpit, seats, mechanical arm, and other structural, interior and exterior parts, together with more than 200 metal and plastic parts, and more than 1,000 standard parts, not to mention the 3.8-meter large-size floor covering, and mastered the composite knowhow from sheet to innovation. The carbon fiber structure based X2 weighs only 560 kg with batteries and can carry two passengers with a maximum load of 200 kg.

Preparation Methods of Graphene Textile Composites for Automotive Industry

Denise Maria Lenz
Ford Motor Company, Instituto Euvaldo Lodi, Doctor of Engineering

This is a short review focusing on graphene addition in synthetic fibers of engineering textiles for automotive industry. Graphene has been provided the development of innovative fabrics in order to enhance properties towards smart textiles. These fabrics are composites composed by synthetic polymers as matrices, graphene as reinforcing agent and many additives which introduce functionalities with synergetic effect in graphene incorporation. Methodologies to achieve a successfully graphene addition in textile composites are described and compared such as deposition in the surface of the yarn/fabric by dipping and padding processes, spraying and printing as well as graphene incorporation by solution mixing, melt mixing and in-situ polymerization methods followed by spinning. The properties and potential applications of these composites as textiles for automotive industry are presented. The challenges and perspectives for the next development steps are discussed.

COMPOSITES IN ELECTRIC VEHICLES

Development and Validation of an EMI Enhanced SMC Compound for BEV Applications

Adam Halsband
Forward Engineering North America, Managing Director

The shift to electrified powertrains and autonomous vehicles is driving an increase in demand for flexible, scalable cost effective structural components. This trend combined with advancements in polymer composite technologies is creating more opportunities for the inclusion of composite structures. However, an unintended consequence of replacing metal components with fiber reinforced polymer (FRP) composite parts is that these alternative parts typically lack intrinsic electromagnetic interference (EMI) shielding wich is otherwise taken for granted with metallic components. Successful EMI shielding solutions require a holistic approach to Design, Materials and Process. Optimal structural composites solutions leverage the attribues of the materials of construction to deliver both mechanical and functional performance. Leveraging this approach the team initiated a program to develop and validate a capable EMI Enhanced SMC Compound. In this presentation, we will share the status of the development of an EMI Enhanced SMC Compound, results of molding and forming trials, insights into the challenges with measuring EMI Shielding Effectiveness and the development of a capable Test Method for Evaluating EMI Shielding Effectiveness of formed SMC Panels, and the results of a comprehensive series of EMI Performance Test Trials conducted on an EMI Enhanced SMC Compound.

Aluminum Coated Basalt Fibers for Automotive Composites with Integrated EMI-shielding

Robert Brüll
FibreCoat GmbH, CEO

The increasing popularity of 5G, IoT and self-driving cars lead to a rising number of electromagnetic waves that cause interference in electronics. To prevent malfunctions, incoming electromagnetic waves and the radiation of emitting devices must be attenuated. This is called EMI-shielding and dye cast metals, metal foils or coatings are used in most applications. While these solutions offer great shielding properties, they are complex to process, limit design flexibility, break easily and are usually expensive. Composite structures with integrated EMI-shielding capabilities would be a replacement for these technologies if they can be produced at a competitive cost. This can be achieved by integrating affordable aluminum coated basalt fibers. By coating aluminum on basalt fibers during the spinning process a multi-filament yarn with high strength, high conductivity and high temperature resistance is produced. At the same time, the material remains affordable as the entire manufacturing process takes place in a single high-speed step. By embedding these fibers into polymers as chopped fibers (LFT, SMC, BMC…) or textiles (woven, non-woven, braided…) attenuations of 50 - 80 dB or more are achieved without compromising mechanical performance. This presentation will give an overview of the shielding needs in EVs, the basics of EMI-shielding and todays solutions. In addition, the production and processing of low-cost conductive fibers for shielding composite parts is outlined.

Multi-material Battery Enclosures: Using Composites for Strong, Lightweight EV Structures

Evan Freeman-Gibb
Teijin Automotive Technologies, Senior Applications Engineer

Teijin Automotive Technologies has developed a strong and lightweight multi-material EV battery enclosure system combining composite tray and cover pieces, aluminum and steel reinforcements, and a steel frame assembly filled with energy absorbing structural foam. This innovative multi-material system showcases the composite material design and manufacturing expertise offered by Teijin Automotive Technologies, and reduces tooling and assembly complexity while being more than 10% lighter than a comparable steel structure. Unique features include the one-piece molded tray and cover to eliminate leak paths, energy absorbers filled with structural foam to reduce weight while maintaining stiffness, and flame retardant composites to contain energy released from cells during a battery thermal event.

Lightweighting and Thermal Management Solutions for EV Battery Pack with Specialty Materials

Somasekhar Bobba Venkat
SABIC, Global Technology Manager Automotive

Range anxiety is one of the primary reasons limiting the mass adoption of Electric Vehicles (EVs). Light-weighting efforts are critical in extending the drive range of EVs. Thermoplastics materials offer light weighting, part integration and design freedom to address critical material requirements for EV application spaces. An exercise is carried out to study the feasibility of materials from SABIC's Specialties business for different components within the battery pack. A modular approach is proposed for the top enclosure for the battery pack which helps in ease of manufacturability, repeatability, and serviceability. The bottom tray of the battery pack supports the weight of the pack and hence requires considerable mechanical strength. A multi-material concept is recommended for the bottom tray to meet the stiffness requirements. The structural performance of the battery pack made of thermoplastic enclosures are tested against different regulatory standards to assess the performance. Another major concern is the thermal management for the safe and efficient performance of battery packs. Thermally conductive LNP(TM) KONDUITTM compounds are explored for a battery module housing. Latest trends in the field of EVs such as wireless connectivity, net zero carbon targets are also discussed in this paper.

Innovative EV Battery and Underbody Shield Designs

Roman Hillermeier
STRUCTeam Ltd,
Head of Transportation Sector

With ever-evolving EV architectures, the industry's stringent safety requirements continue to grow. The battery enclosures are at the center of this development challenge. Battery enclosures must be designed with consideration for the safety of the battery, the occupants, and the vehicle's overall performance. Battery enclosures are generally large and invasive components positioned in the center of the vehicle. They are used not only to protect the battery cells, but also have the potential to increase the torsional stiffness and driving performance of the vehicle. As a result, efforts to embrace the battery enclosure's role as a structural component are logical and have garnered the automotive industry's attention. Automotive manufacturers are looking for novel integrated designs and sustainable material innovations. Recent findings support the increasing advantage of multimaterial solutions. This presentation will address the latest research on requirements for battery enclosures, including its protective underbody shields and identify the key engineering enablers of multimaterial designs. These new multimaterial designs are achieved by novel integration of both structure and function. The resulting battery enclosures use a unique combination of materials, with the right composite materials being used in areas to yield the highest maximum benefits. In addition to engineering and commercial considerations, the sustainability aspect of these new solutions will be discussed.

Multi-Material Structures for Commercial Electric Vehicle Chassis Applications

Rachel Weare
WMG, Lead Engineer - Structural Composites R&D

The current EV chassis trend is moving away from traditional unibody structures towards a body on frame strategy, seen as the most efficient way to package batteries and hold EV architectures. eSHADOW (Electrified Structural Hybrid Automotive Designs for Optimised Weight) aims to bridge the gap between current EV unibodies and expensive skateboard platforms using a hybrid multi-material approach to provide an affordable ultra-lightweight rolling chassis for a Ford Transit van. Gestamp Chassis are designing a fully optimised ladder frame that could be deployed to all body on frame vehicles and will be demonstrated by the production of several full-size ladder frames for complete vehicle performance assessment. The performance of the frame will be evaluated against relevant benchmarks and physical test data. The Automotive Composites Research Centre at WMG, The University of Warwick, UK is conducting comprehensive multi-material evaluation, joining characterisation, DFM and process development of selected composite manufacturing technologies. The presentation will review the existing moulds being used to de-risk final prototyping of the complex structural components; a hybrid design of continuous and discontinuous CFRP to be manufactured at WMG later this year in an automated process suited to high-volume manufacture.

Thermoforming of EV Battery Top Cover Using Glass-Filled Intumescent Fire Retardant Polypropylene

Dinesh Munjurulimana
SABIC, Lead Scientist

To meet the stringent regulations of carbon emissions worldwide, the automotive industry is moving towards developing electric vehicles (EVs). Weight reduction and thermal runaway protection are key enablers. The existing EV battery pack components like top cover and bottom tray are predominantly made out of sheet metal forming, primarily due to lack of mature alternate large-scale manufacturing processes. This result in battery packs that are heavy, less efficient and limits integration possibilities. Thermoplastics, on the other hand, can offer immense potential for light-weighing, functional integration, and improvement of performance and efficiency. The present study addresses the existing challenge of manufacturing large-scale parts such as EV battery top cover, using thermoplastic composite materials. More specifically, it demonstrates the use of novel thermoplastic composite material, a 30 % glass-filled, intumescent, flame-retardant (FR) Polypropylene (PP), for a top cover application using extrusion and thermoforming. The composite material was extruded into flat sheets using single screw extruder. The extruded sheets were thermoformed into multiple prototype geometries, from small to large-scale, to validate formability of the material. It was observed that thermoforming of extruded sheet into a full-scale EV top cover is feasible capturing complex geometric features, therefore, establishing its applicability for actual scale battery pack components like top covers.

Use of Graphene in Sheet Molding Compound (SMC) for Applications in Electric Vehicles

Layne Gontijo
Ford Motor Company, Researcher

The interest in electric vehicles has grown recently due to concerns over air pollutants emissions contributing to sustainable development. Establishing the transition from conventional combustion engines to electric powertrains reduces fossil fuel consumption and noise pollution due to their silent electric motors. In this context, composite materials became a great ally in performing the motor transition, as they combine mechanical resistance with lightness using innovative structural designs. The sheet molding compound (SMC) is an economical product that consists of a mixture of fiberglass, additives, catalysts, and mineral fillers embedded in an unsaturated resin. To improve the structural properties and reduce the weight, nanomaterials such as graphene can be added to the manufacturing process resulting in a significant increase in mechanical properties, stiffness, shear strength, and modulus, demonstrating superior properties to traditional parts and providing good technical processing feasibility, consequently generating new materials. It may be used to replace conventional materials when applied in polymeric composites, such as metallic and other polymeric materials existing in vehicles. From this innovative perspective, the incorporation of graphene enhances the composite's performance by achieving weight reduction without loss of properties for structural and non-structural applications, particularly to electric vehicles.

ENABLING TECHNOLOGIES

Impact from UT Uncertainty in Quantifying Ply Stack Orientation on Probabilistic Failure Envelope

Kirtunia Rahul
Baylor University, Doctoral Candidate

Ultrasonic-Testing (UT), a popular technique among Non-Destructive-Testing (NDT) for the inspection of new and in-service parts in automotive & aerospace industries is used to identify defects, but not often used to correlate to that of the effective composite laminate properties. With the advancement of NDT waveform analysis, the ability to determine the individual ply-orientation on a lamina-by-lamina of Carbon-Fiber-Reinforced-Polymers (CFRP) has improved from an accuracy of ±10° to ±2°. This paper investigates the impact of this deviation on the confidence in characterizing the stiffness and strength of CFRP laminates from UT data set that generates ply stack orientation from inspection by utilizing the failure envelope from Tsai-Hill failure model and investigates probabilistic Cumulative-Density-Function (CDF) of First Ply Failure (FPF) stresses using Monte-Carlo Simulation technique. To find FPF, Tsai-Hill criteria is used by applying unit longitudinal and transverse radial load from 0° to 360°. In this study, CFRP laminates consisting of 8, 12 and 16 plies with a variety of layup sequences are analyzed and probabilistic failure envelope is established by MATLAB code. A comparative analysis of before and after improvement in characterizing the probabilistic failure envelope using current high-resolution UT data and analysis is illustrated for a proper understanding of how the properties of CFRP are impacted by an increased confidence in the underlying ply-orientation.

Automation and Digitalization for the SMC Compression Molding Process

Louis Kaptur
Dieffenbacher, Head of Business Unit Forming North America

Sheet Molding Compound (SMC) is a well-established composite material used in high volume applications for a wide range of industries including automotive electric vehicles. For decades, the compression molding process of SMC has required operators to manually cut, stack and weigh the SMC material as well as manually load and unload the material into a hydraulic press. With labor shortages and the movement to advanced manufacturing, automating the SMC compression molding process has become increasingly important. As a leading supplier of composite production machinery, Dieffenbacher has developed complete turnkey SMC compression molding production cells including: SMC unwinding, cutting, stacking, weight, loading, unloading, and post processing. This automated technology is enabling the SMC industry to increase productivity and throughput, helping SMC molders achieve higher yearly production volumes. Additionally the use of automation enables molding of complex parts in a repeatable way while maintaining a high part quality. This presentation will give an overview of Dieffenbacher's complete turnkey SMC production cells with detail on the individual subsystems that automate the SMC compression molding process. Lastly, we will present our Digitalization solutions including anomaly detection, quality prediction, reporting and trending, condition monitoring and other features, which will help molders better understand and control their production plant.

ATSP's NOWE Mold Release Coating

Jacob Meyer
ATSP Innovations, Inc., VP of Technology

ATSP Innovations Inc., Houston, TX, has developed an innovative coating that could be beneficial for resin and composite molding tooling. ATSP's NOWETM coatings, developed for metals such as steel, titanium or aluminum substrates, are high temperature & wear durable, chemical & corrosion resistant, polyester powder coatings. When used with PTFE the composite coating has excellent temperature, improved wear resistance, and chemical durability along with low coefficient of friction surface performance. Applications of NOWETM coatings with PTFE includes, but not limited to, valve/pipe corrosion protection, low friction bearing tough surfaces, polymer/composite molding tools and plasticization equipment. Especially for compression/injection molds and extrusion/pultrusion dies, the NOWETM coatings could reduce the need for continual applying mold release and die surface treatments such as chrome coatings while reducing the large ejection force on the contact side between the core and molded product that causes such molding defects as cracking or deformation. NOWETM coatings exhibit dimensional stability with the superior performance at extreme environments from -200°C to 300°C.

Rapid Curing Epoxy Systems for High Throughput Production of Lightweight Composites

Prashanth Badrinarayanan
Olin Corporation, Group Leader, Wind and Composites R&D

High Pressure Resin Transfer Molding (HPRTM) is an efficient process for high throughput production of lightweight automotive composites. While resin formulations developed for HPRTM are expected to cure quickly, changes in cure temperature or cure duration depending on processing constraints may induce variations in extent of cure. It is of significant interest to determine whether such variations in the degree of cure could hamper the attainment of desired mechanical properties at the composite scale. In this work, we present a robust epoxy resin formulation, which delivers optimum mechanical properties, for varied processing conditions through development of a strong interface with the fiber reinforcements. The effect of nominal cure level variations on the mechanical properties of unidirectional fiber reinforced composites fabricated by HPRTM is investigated in this work through an in-depth evaluation of tensile performance, flex performance, and interlaminar shear strength (ILSS).

MODELING OF COMPOSITES
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Replacing Metal with Continuous Fiber Reinforced Thermoplastics

Louis Kaptur
Dieffenbacher, Head of Business Unit Forming North America

Light weighting is becoming increasingly important for new electric vehicle architectures as well as SUVs and Trucks. This has created an increased demand for lightweight high performance materials such as continuous fiber reinforced thermoplastics. This presentation will look at an automotive product case study, where a multi component metal subassembly is replaced with a single continuous fiber reinforced thermoplastic structure. A high-speed automated press cell was utilized to form the continuous fiber reinforced thermoplastic blanks at high volume levels. As a next step for reducing manufacturing waste, the state of the art Dieffenbacher Fiberforge tape laying system and the Fibercon tailored blank consolidation system, are employed to manufacture part specific continuous fiber reinforced thermoplastic tailored blanks for forming. The production process will be described in detail for this novel use of continuous fiber reinforced thermoplastics in an automotive application.

HP-RTM and LCM Applications for Automotive Industry

Gleb Meirson
Fraunhofer Innovation Platform, Research Engineer

High Pressure Resin Transfer Molding (HP-RTM) is a state of the art process designed to produce structural composite parts at high volumes. HP-RTM process was used by a number of European OEMs since early 2000s and the first automotive parts using this technologies in North America have been announced in 2021. Today HP-RTM is utilized in production of several different parts for automotive applications in North America such as leaf springs. A newer modification of HP-RTM is called Liquid Compression Molding (LCM). LCM process is an adaptation of HPRTM that allows for shorter cycle times but at the expense of geometrical flexibility. Fraunhofer Innovation Platform @ Western University (FIP@Western) is working on integrating the LCM process into the North American manufacturing environment. LCM has been fully automated at FIP and was utilized in production of simple and complex geometries. During the production critical process parameters were explored. The experiments showed that while for simple geometry the envelope of operation is very wide the complex geometry was found to have a very narrow operation envelope and the mold requires modification from its original HP-RTM design.

Development of Forming Limit Diagrams for Dry Fabrics

Chandra Kishore Reddy Emani
University of Michigan - Dearborn, Graduate Student

Fabric-reinforced polymer composites are being considered for many structural automotive applications because of their weight saving potential, high structural performance, and design flexibility. The manufacturing process for making these composite parts starts with making a preform of dry fabrics if a thermosetting polymer is used as the matrix or with press forming operation if a thermoplastic polymer is used as the matrix. During the press forming operation, the fabric is subjected to a complex set of deformations involving shear, tension and bending. The limits of the press forming operation are determined by the ability to produce and retain the shape of the preform without developing defects, such as fiber distortion, wrinkling, and tearing. In this study, we consider the development of two of these defects, namely wrinkling and tearing, in a press-formed dry plain woven glass fabric using a die-punch setup, and using finite element analysis, determine the forming limit of this fabric as a function of blank holder force and forming depth. It is shown that the punch corner radius has a critical role on the forming limit of the fabric.

Towards a Virtual Process Chain for GMT as Basis for Digital Product Development

Dominik Dörr
University of Western Ontario (UWO), SIMUTENCE GmbH, Postdoctoral Associate

Chopped fiber materials reveal the potential to be used for complex geometries, offering great potential for functional lightweighting. The material targeted within this study is Tepex flowcore, a long glass fiber reinforced polyamide (PA/GF) glass mat manufactured by Lanxess. Tepex flowcore consists of long glass fibers with random orientation and belongs to the material class of GMT with an engineering polymer, i.e. PA6. Press molding of flowcore can be divided into two different stages, namely thermoforming and squeeze flow, which can include challenges like local wrinkling and incomplete mold filling, respectively. Moreover, manufacturing might be accompanied by process-induced deformations (PID) after solidification and ejection from the mold. In this study, experimental molding analyses are presented and the requirements for a virtual process chain for GMT materials are derived.

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Dominik Dörr ***(continued)***
On this basis, a sequential simulation approach including the sub-steps thermoforming, squeeze flow, and PID simulation is presented. Using this approach, the best-suited numerical technique is chosen for each sub-step, while constitutive modeling remains continuous through a unified material modeling approach and the retainment of relevant state variables, such as fiber orientation or temperature. The virtual process chain is applied to different geometries with varying complexity and the benefits and challenges for digital product and manufacturing process development are motivated.

Predicting Crystallization-Dependent Residual Stress Development in Thermoplastic Composites
Nithin Kaliyath Parambil
Center for Composite Materials (CCM), Postdoctoral Researcher
Fiber reinforced thermoplastic composites are attractive for automotive applications due to their increased throughput potential over their thermosetting counterparts. Understanding and predicting thermal residual stress is a key factor in designing components to maximize performance by reducing warpage/defects and optimizing the processing method. Thermal residual stress, resulting from the coefficient of thermal expansion (CTE) mismatch of the matrix and fiber, can be significant because of the large thermal gradients between melt/processing and service temperatures. Further residual stress can be induced upon crystallization if the matrix exhibits crystalline/semi-crystalline behavior. A computational model predicting the process-induced residual stress is developed for AS4/polypropylene micro-composites and implemented via user material subroutine (UMAT) in ABAQUS. The model includes the cooling-rate dependent crystallization, temperature-dependent elastic modulus, and temperature-dependent CTE of the matrix, and the temperature-independent transversely isotropic properties of carbon fiber and can replicate the experimental conditions (initial fiber preload to prevent buckling) and process history. Post-process, micro-Raman spectroscopy is utilized to validate and quantify the residual strain developed in the fiber for different preload (1 - 8 g) far away from the free edge of the sample.

Measurement and Simulation of In-Plane Permeability for Resin Transfer Molding Process
Anand Bora
Moldex3D Northern America, Inc., Customer Success Manager
Permeability is one of the most important parameters for the fiber reinforcements for resin transfer molding (RTM) process. However, there is no standardized experimental method for measuring permeability, and the values measured by different methods may be not consistent. In this work, both 1-D flow mold and radial flow mold systems are used to obtain the in-plane permeability. Furthermore, the experimental mold dimension and process parameters are established in Moldex3D as the digital twin. Various rotational angles are used to study the anisotropic flow behavior. By the validation between physical experiments and digital twin, one can obtain the material parameters more precisely.

Material Characterisation and Predictive Analysis of Chopped Fibre Structures
Tim Hall
Engenuity Ltd, Commercial Director
Detailed material testing and characterisation is essential to the subsequent accuracy of finite element analysis (FEA) predictions. The processes that Engenuity have developed in their in-house laboratory will be presented - from coupon preparation, through DIC strain recovery and data processing, to material card creation for FEA codes. Analysis of chopped fibre composite materials such as SMC present a particular challenge due to the random orientation of the reinforcement fibres. Traditional methods tend to lead to over-engineered and hence over-weight parts with little visibility of variability. Engenuity have developed a stochastic method for material characterisation and predictive analysis of such structures - known as FiRMA. The technical background and capabilities of FiRMA will be presented, demonstrating its ability to simulate the inherent performance distribution of an SMC component, and hence how the technique can be used to produce efficient, optimised parts.

A Review on the Constitutiuve Models Applied in ABS, PC/ABS Polymers and Graphene Nanocomposites
Lamartini Barazzutti
Euvaldo Lodi Institute / Ford Motor Company, Researcher
Development of novel materials has always drawn attention of researchers and driven/shifted the economy in some way. Polymeric materials as particularly interesting to automotive industry as they present heat, abrasion and vibration resistance, design freedom and vehicle comfort and safety. However, these materials have limitations such as degradation at high temperatures and lower mechanical strength compared to metals. Because of this, there is an exhaustive search for composite materials that,

combined with other polymers, can reduce these limitations. In this context, graphene and derivatives have shown remarkable results as in improving mechanical properties, but lacks information regarding numeric simulation in the literature. It is introduced a brief explanation about polymers mechanical properties, rheological models, elastic-plastic models. Macroscopic and micromechanical approaches to model graphene nanocomposites are addressed as well. Therefore, this paper's purpose to review the literature about numeric simulation applied in ABS, PC/ABS polymers and present means to reproduce these models to assess graphene nanocomposites properties.

Modeling of Wrinkle Formation in Non-Crimp Dry Fabric during Preform Compaction

Von Jamora,
Old Dominion University,
Ph.D. Candidate

Lightweight components in the automotive industry need to be draped into complex parts during liquid molding. Composite dry fabric can develop wrinkles and fiber waviness during the preform compaction stage. As a result, the compaction of the textile can result in defects, such as wrinkling which affect the local fiber volume fraction variation. Therefore, to simulate the compaction of the dry quadaxial non-crimp fabric, a finite element analysis (FEA) framework was developed. The custom material subroutine was made to simulate the non-linear deformation of dry fabric preform. The constitutive material model used the superposition of an elastic and a viscous component. The elastic part used an isotropic hyperelastic behavior, and the viscous part was composed of a strain and a strain rate dependent element, which are functions of the fiber volume fraction and compaction speed, respectively. The stress-strain response from a unidirectional compaction test, with varying compaction speeds, was used to define the viscous behavior. The FEA model of wrinkle formation due to the cylindrical roller compaction shows a close correlation with the experimental test demonstrated in the stress strain behavior. Results of the analysis demonstrate the fiber volume fraction varies through the thickness and voids can be seen forming due to the wrinkling between layers.

Effects of Out-of-plane Ply Wrinkles on the Pre and Post-buckling Behavior of Carbon Fiber Reinforced Composites Using Finite Element Analysis

Amir Nasirmanesh
Baylor University,
Doctoral Candidate

Carbon Fiber Reinforced Polymer (CFRP) composites are heavily used in different industries such as aerospace, automotive and naval due to their unique characteristics such as high strength to weight ratio which makes them an ideal structural candidate for these applications. However, due to their delicate and complex manufacturing process a slight variation in the process can introduce defects in the structure of the composite. One of these common defects is when the different layers are not straight, producing an out of plane wrinkle in the internal lamina layers. In these composites, buckling is one the most common failure modes for composite laminates jeopardizing the integrity of the whole structure. In this study, the problem of buckling induced delamination will be addressed for composite laminates using Finite Element Analysis (FEA). For this purpose, A fully automated MATLAB code has been developed to get the required geometrical and material information such as wrinkle parameters and layup configuration from the user and then generate the FEA model to be run in Abaqus. Also, the effect of the wrinkle shape on the location of delamination cracks and their propagation will be studied. Results show that an eigenvalue buckling analysis cannot estimate the critical buckling loads for wrinkled laminated composites which makes performing a detailed post-buckling analysis necessary.

FINALIST FOR BEST PAPER AWARD

Reconstruction of Full Fiber Orientation Distribution in Molded Composites

Mohammad Nazmus Saquib
Old Dominion University,
Ph.D. Candidate

Molded composite materials are key to functionality, mobility, and sustainability of electric vehicles (EVs), on demand air mobility and aerospace structures. Fiber orientation distribution (FOD) characterization of composite materials are necessary to understand the mechanical variability in prepreg platelet molded compound (PPMC). A novel U-Net deep learning model was developed to predict local through-thickness fiber orientation (FOD) field in PPMC composites. The deep learning model was trained with synthetically generated PPMC morphologies. Thousands of virtual PPMC plates were subjected to uniform temperature change. The induced thermal strain components on the surface of PPMC plate were used to train the U-Net model to predict average through-thickness FOD in the entirety of the molded plate. A heating stage with digital image correlation (DIC) setup was used to analyze the thermal expansion behavior of PPMC samples. The trained deep learning U-Net model was used to make a prediction of FOD in a physical part by providing surface strain fields collected through thermal DIC. The obtained U-Net model prediction of FOD was compared to FOD obtained through microscopy and image analysis. The predicted non-uniform behavior of FOD compared with the experimentally measured FOD along the several polished cross-sections revealed close comparison. The present results indicate the opportunity for rapid inspection to detect manufacturing induced FOD in molded composites.

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Sustainable Recycled Polycarbonate (PC) based Blend & their Biocomposites

Neelima Tripathi
University of Guelph, Postdoc Scholar

This work focuses on developing thermoplastic blends and bio-composites by utilizing a combination of bio-sourced, recycled and waste resources. The sustainable blends and bio-composites, prepared by an upcycling approach, will be beneficial for reducing the cost and CO_2 emissions of the automotive parts while improving vehicle performance and preserving limited resources. This work focuses on utilizing recycled PC (rPC) as a matrix for one such material. The bio-based content of the matrix was enhanced by incorporating renewable poly(lactic acid) PLA. A small amount of hydrolytic stabilizer (BioAdimide) in PC:PLA blend has proved to make the products durable and weather resistant for automotive applications. The addition of PLA resulted in improved melt flow properties by 34% in the rPC/PLA compatibilized blends. The mechanical strength of the compatibilized blends of rPC and PLA were tested. In addition, lignin (waste from paper and biofuel industries) was pyrolyzed at 500°C to prepare a bio-carbon (having functionality) to include as a reinforcing agent. From these materials, lightweight, sustainable bio-composites were developed using biocarbon, recycled carbon fibers (rCF) and recycled PC/PLA blends. The final, lightweight bio-composites prepared by injection molding showed enhanced properties. This novel work developed biocomposites with more than 90% sustainable content (that includes recycled, bio-source and waste resources) supporting a groundbreaking circularity.

Use of Nanofibrillated Cellulose in Thermoplastic Biocomposites for Eco-responsible Auto Interiors

Mihaela Mihai, *National Research Council of Canada, PhD, Senior Research Officer*

Current environmental changes mandate for actions to be taken by players from all industries. The automotive industry needs to decrease vehicles fuel consumption and emissions. The main solutions are the weight reduction of vehicles, introduction of renewable, bio-sourced materials and of recycled materials in car parts. The utilization of most common automotive plastics, such as polypropylene (interior applications) and polyamides (under-the-hood applications), can be reduced by using cellulosic fibers, a renewable natural polymer. This work presents the way of use of nanofibrillated cellulose (NFC) in the development of biocomposites for automotive interior parts. NFC, cellulose fibrils belonging to the nanocellulose reinforcement category, are produced from Northern Bleached Softwood Kraft pulp (NBSK) by a chemical-free top-down mechanical refining process which results in fibrils of high strength, purity, aspect ratio, and surface area. NFC fibrils were used as reinforcements in PP, PA6, recycled PP (rPP), and polylactic acid (PLA) matrices to obtain novel biocomposites. The mechanical performance (tensile, flexural, and Izod impact) and the thermal properties (coefficient of linear thermal expansion, heat deflection temperature) of biocomposites presented increments compared to initial matrices but, also, when compared to currently used materials. Our eco-friendly NFC-based materials shown a high potential to replace the petroleum-based ones in automotive interior parts.

Upcycling of Biomass and Food Wastes in Engineering PP-based Biocomposites for Auto-parts Uses

Arturo Rodriguez Uribe
University of Guelph, Research Associate

We engineered advanced biocarbon through pyrolysis of waste wood chips, corn cob, Miscanthus grass, crab shell and shrimp shell. The developed sustainable fillers on reinforcement with polypropylene (PP) result in the development of light-weight biocomposites. Through reactive extrusion followed by injection molding the test samples were made for their performance evaluations. The biocarbon developed at >700°C present functionality over carbon surface unlike those made at >900°C pyrolysis temperature. High temperature biocarbon (~900°C) showed improved interfacial adhesion towards polypropylene (which is a hydrophobic plastic). Biocomposites manufactured with high temperature-made biocarbon exhibited higher modulus as compared to low-temp-made counterpart. Again the use of maleated-g-polypropylene (MA-g-PP) helped in improving the overall performance of the developed biocomposites. The particle size reduction of biocarbon has a profound effect on the performance of the resulting composites. The combination of particle size reduction with the maleated coupling agent has a dramatic bonding effect thus on the performance of the resulting biocomposites. The developed biocomposites with 27wt.% sustainable biocarbon fillers showed density of ~ 1 gm/cm3 making those quite lighter as compared to mineral-filled counterparts. Such light biocomposites from waste resources show significant potential in the development of light-weight auto-parts.

Eco-responsible Parts for Automotive Interiors Made from Nanofibrillated Cellulose and Polypropylene

Mihaela Mihai, *National Research Council of Canada, PhD, Senior Research Officer*

The emergency created by current environmental changes mandates for immediate solutions for decreasing gas emissions of vehicles. Transportation sector is responsible for 25% of the total GHGs emitted where car weight fingerprint is critical. The weight-lightening of cars can be done by using eco-friendly materials and recycled polyolefins without loss of performance of final parts. Our paper discloses the advantages of using Nanofibrillated Cellulose (NFC) in environmentally-friendly polypropylene biocomposites. We present three NFC biocomposite solutions for the manufacture of lower-weight parts such as headliners, dashboards, door panels, bolsters.

Reclained Carbon Fibre Based Sustainable Solutions for Automotive Structures

Somasekhar Bobba Venkat
SABIC, Global Technology Manager Automotive

The quest for attaining light weighting in the automotive industry is ever evolving. Eco-friendly products and sustainable design solutions will influence the future for the automotive industry. With sustainability at the forefront, this paper targets an automotive tailgate application made with injection molded long glass fiber (LGF) materials and considers the use of an alternative material - short carbon fibers. The carbon fibers used are reclaimed and predominantly discarded by aircraft industry. The higher stiffness and lower weight of carbon fibers as compared to long glass fibers becomes the impetus for this exploration. A computer aided engineering simulation (CAE) approach was undertaken and a parallel was drawn between the LGF and reclaimed carbon fibers (RCF) filled tailgate using injection molding and structural simulations to make an assessment. The inherent benefits of using RCF translates to reduced weight and cost. The work done toward achieving a part which is structurally efficient, dimensionally stable and more importantly sustainable, as compared to a LGF filled part, becomes the core of this work.

Characteristics of Biochar Produced from Cellulose for Atmosphere CO_2 Capture

Lidia Lazzari
Ford Motor Company - Brazil, Technical Specialist - Research and Innovation

Biochar (BioC) production, from biomass, is attractive due to its low cost and relevant physicochemical characteristics. Within this context, the objective of the present work was to produce BioC from cellulose of Pinus elliotti, with different pyrolysis parameters, to use it on the CO_2 adsorption, from atmosphere. As main results, the produced BioC presented a porous structure, with a fibrous characteristic, due to the raw material used (cellulose). In the same way, those P800 presented specific surface area and total pore volume higher than those P600, due to the higher pyrolysis temperature applied. Due to these characteristics, P800 presented a greater ability to adsorb CO_2. Thus, a potential use for BioC was identified in this work.

Sustainability Through Sandwich Construction and New Stronger, Lighter & Greener Core Materials

Russell Elkin
3A Core Materials/Baltek Inc., Product Development Manager USA

Especially for automotive applications, environmental sustainability is driven not only by production and end-of-life considerations, but predominantly the use phase. To reduce this footprint, de-massification is a highly relevant factor that not only helps bring down energy consumption but also improves secondary effects (wear and tear, etc.), leading to substantial decrease in total costs of ownership. One of the key principles for lightweight structures is sandwich design: a combination of thin, stiff skins with lightweight core material, allowing weight reduction up to 60%. PET foam core from post-consumer rPET grade plastic and renewable balsa based cores from FSC® certified plantations are best positioned to enable sustainable lightweight applications. Discussion will include material supply chains with focus on sustainability, mechanical performance & key benefits, as well as examples of parts currently in production with proven short-cycle, high volume processes.

Ocean Recycled Nylon and Lignin Biocarbon-based Sustainable Biocomposites for Auto-parts Uses

Victoria Muir
University of Guelph, Undergraduate Researcher

Traditional non-renewable petroleum-derived plastics present increasing environmental concerns observed through rising plastic pollution, where currently over 8 million tons of plastic are entering oceans annually. The use of recycled and agro-waste products in developing automotive parts supports the movement towards a circular economy. This work focuses on developing biocomposites using ocean recycled nylon (ORN) for high-performance automotive applications. Lignin (waste from pulp and paper industries) was carbonized at 600 and 900°C as a sustainable filler for biocomposites. The influence of carbonization temperature on the thermal, structural, surface morphology, and mechanical properties of ORN biocomposites was analyzed. A decrease in melt flow index was observed by adding the BioC as a filler in the matrix. Compared to the non-functional 900°C BioC, 600°C BioC showed reduced MFI which might be because of the better interfacial interaction of 600°C BioC with ORN. Adding lignin biocarbon (BioC) to ORN enhanced its flexural strength and modulus. The tensile strength and tensile modulus also increased in biocomposites with respect to the neat ORN. The mechanical properties were further enhanced with the addition of maleated compatibilizers. The developed biocomposites have the potential to be used as automotive parts.

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Sheet Molding Compound EV Battery Applications - High Performance & Sustainable Material Solution

James Bono
Polynt Composites USA, Technical Manager

Polynt will present a class of solutions based on fiber-reinforced plastics (FRP) sheet molding compounds (SMC) to be used by hot flow molding process (short cycle times, very little material waste) and focused on sustainable mobility (lightweight, e-mobility, renewable and/or recycled raw materials, re-use at the end of life). Polynt will include an evaluation of several high performance resin systems in this paper as well as the effect of fiberglass and carbon fiber on structural SMC systems for battery enclosures. The high lightweight potential of fiber-reinforced plastics (FRP) is based on the fact that high durability, advantageous mechanical performance, design freedom, low weight, and ease of manufacturing can be achieved with very low density at the same time. The possibility of substituting conventionally manufactured components with mechanically equivalent but significantly lighter FRP components is particularly attractive in the mobility sector, where lightweight solutions can result in both lower moving masses and larger payloads with the same overall weight, turning to a significantly lower fuel consumption and thus lower emissions of climate-damaging CO_2. With the Polynt eco-friendly SMC solutions we can demonstrate that a closed life cycle can be achieved. We are able to use bio-resin, regrind fillers and recycled reinforcements under the respect of SVHC freedom for demanding part solutions.

Advanced Bio-carbon from Waste Burlap Biomass for Improved Thermal Management of Biocomposites

Haftom Weldekidan,
University of Guelph - Bioproducts Discovery and Development Center

Bio-based composites have numerous applications in diverse fields of our everyday life including the automotive industry and in construction materials, aviation as well as around electronics and electrical engineering. Biocarbons from different sources have been found to be effective fillers in enhancing the flammability and mechanical properties of composites. With this in mind, we have produced highly advanced biocarbons from waste burlaps at different operating conditions and studied the mechanical strengths and flammability of the composite materials processed with polypropylene as the matrix. The first biocarbon was produced at 600°C (called BC600 hereinafter), and this biocarbon sample was further pyrolyzed to 1200°C with and without catalyst (BC1200 and BC1200C) to produce the other two biocarbon samples. Metallic catalyst was utilized to prepare the advanced biocarbon, and percentage of catalyst was 2%. The biocomposites manufactured with 80% PP and 20% of BC1200C has the highest flex modulus which was 30% greater than the neat PP. Smaller particles are better encapsulated in the polymer matrix which improved dispersion and resist deformation for flex and tensile forces. But the main reason for the higher flexural and tensile modulus of the specimen was the high content of highly graphitized biocarbon in the BC1200C. The biocomposites made from catalyzed advanced biocarbon reduced the flammability of PP significantly.

Recycling Automotive PET Carpet Trimmings

Alfonso Martinez, *University of Waterloo*

Non-woven fiber mats are used in automotive application as carpet and other application for noise management. A preferred material is based on polyethylene terephthalate (PET) fiber and other resins due to its optimal balance of durability, easy of manufacturing and performance. Most commonly, components are manufacture by thermoforming using complex array of fiber and sheets. The parts are trimmed after thermoforming to achieve its final size. The quantity of trimmings varies significantly, but in some cases, it can be in excess of 50%. This results in a large amount of by-product when utilizing this manufacturing method. Unfortunately, due to the complexity of this materials most trimming are sent to landfills. The main challenge in recycling these resins is the significant decrease in viscosity when attempting to reprocessing and recycling. This research is looking into strategies to enable recycling of PET trimmings from automotive manufacturing utilizing chain extenders. Our preliminary results have shown that using suitable chain extenders and condition for reactive extrusion, it is possible to produce a pellet of recycled PET with intrinsic viscosity above 0.65 dL/g. This technology would enable recycling PET carpet trimming and avoid sending automotive waste to landfill.

KEYNOTE PRESENTATIONS

The Journey To a Composite Battery Enclosure

Dave Sullivan,
Electrification Marketing Manager Americas, SABIC

Abstract not available at press time

Advanced Polymer Composites for Next Generation Electric and Autonomous Vehicles (EV/AV) - Challenges and Opportunities,

Dr. H. Felix Wu, *Senior Technology Manager in Vehicle Technologies Office (VTO), Office of Energy Efficiency and Renewable Energy (EERE) at the U.S. Department of Energy (DOE)*

The presentation will provide an overview of science and innovation developed from the ongoing VTO's Composites Core Program. New research on multi-functional materials utilizing advanced polymer composites to reduce manufacturing cost and carbon footprint, overall embodied energy of the vehicle as well as weight saving of electric vehicles will also be discussed. "Multi-functional materials will allow design of automotive components capable of undertaking multiple functions, increasing battery specific energy capacity, reducing the number of vehicle components and thus overall weight and total cost," said Wu. "Such composite materials and structures systems with autonomous health management could transform the current EV/AV platform," added Wu.

Material Innovations in EV Battery Enclosures including UL Solutions' Battery Enclosure Material Screening (BEMS),

Daniel O'Shea,

Principal Engineer, UL Solutions

EV batteries typically cover the entire base of a vehicle. Materials used to house these batteries must be able to withstand high temperatures, pressure, and mechanical impact in order to provide the required safety function. As the automotive industry looks to lightweight many components, battery enclosure materials are increasingly changing over to plastics and composites. Choosing the appropriate enclosure material before building an expensive prototype is critical. We will review the hazards associated with a thermal runaway event and discuss available methods to evaluate plastic and composite materials for safety in and around battery enclosures. The discussion will include:

- Brief background on electric vehicle (EV) battery packs
- Description and examples of thermal runaway events
- Available methods for the evaluation of plastic and composite materials for battery applications, including the Battery Enclosure Thermal Runaway (BETR) Evaluation

Daniel ("Dan") O'Shea, with Underwriters Laboratories since 1996, is UL Solutions' Principal Engineer for Emerging and Growth Markets under its Engineered Materials operations. He is a global expert in Material Characterization and Hazard Based Safety Engineering (HBSE) in the field of Testing, Inspection, and Certification (TIC) for Electronics and Electrical Equipment (E&E), Transportation, Energy, Consumer Medical & Information Technologies, Appliances, Lighting, and other industries

Using the principles of Lean Sigma, he drives global consistency, integrity, and engineering quality in the development, maintenance and application of test requirements and delivery of UL Solutions' conformity assessment services globally in Europe, the Americas, and Asia-Pacific.

He is an active expert on many international technical committees including IEC TC89 on Fire Hazard Testing, IEC TC112 on Electrical Insulating Materials & Systems, ISO TC61 on Plastics, ASTM D20 on Plastics, and ASTM G03 on Weathering and Durability, as well as Technical Adviser to Proficiency Test Programs in both ASTM and IECEE-CTL.

He is one of UL Solutions' Distinguished Members of Technical Staff (DMTS) and has received Underwriters Laboratories highest employee award, the Mark of Excellence. He has been recognized for his contributions to standards by ASTM, received the 1906 Award for his work within IEC, and is a Senior Member of the Society of Plastics Engineers (SPE).

Opportunities for Composite Material in Future Multi-material Battery Enclosures,

Warden Schijve,

Design Leader, AZL Aachen GmbH

The keynote presentation will highlight the project results including analysis and comparisons of both thermoset and thermoplastic materials, solid laminate and sandwich solutions, short fiber overmolded solutions, various SMC options, steel, aluminum, and combinations of all these materials. All relevant load cases were considered in the CAE analysis, as defined by safety regulations, in combination with specific OEM requirements. Due to new requirements on fire resistance during thermal runaway, the presentation will also highlight experimental fire testing on different materials and protective layers currently being performed. This testing includes measurement of material strength under fire loading. Next to this, high-speed foreign object bottom penetration resistance of various material solutions are also being tested, to better estimate protection levels for future battery pack layouts such as cell-to-pack.

Warden Schijve is currently Design Leader at AZL Aachen GmbH, leading a team of senior engineers. His field of work involves concept design, CAE methods, cost analysis, composite processing, prototyping and industrialization. He led a one-year consortium project with 46 participating companies on multi-material battery casing designs. It yielded 20 different concepts designs, CAE analyzed to all relevant load cases and compared on cost and weight with a state-of-the-art metal design. Currently he's also leading follow-up projects on battery pack fire safety and impact protection.

Prior to AZL, he was Chief Scientist Composites at SABIC, where he led application development for continuous-fiber thermoplastic composites. With SABIC for 15 years, he was previously Group Leader Application Development for long, discontinuous fiber materials. Before SABIC, he spent 10 years at DSM as a Design Engineer and Project Leader Material, Process, & Design Development for PP-LFT and other materials. Earlier in his career he spent 11 years at Fokker Aircraft, where he began with conceptual design of thermoset composites and later became Project Leader Thermoplastic Composites. He began his career spending a year in the TNO Prins Maurits Laboratory, where he developed simulation methods to predict explosive blast damage in ships. He earned his degree in Aerospace Technology from Delft University.

KEYNOTE PRESENTATIONS (CONTINUED)

Setting up Local HV Competencies, Wolfgang Maluche, *VP Engineering, Engineering & Planning Center (EPC), Volkswagen Group of America*

Volkswagen is focusing on the global transformation to electric mobility with the ID fleet of vehicles. In the North American Region, VW recently introduced the first locally manufactured EV – the ID.4. Volkswagen's Engineering department is strongly investing in key competencies and high tech equipment for electric vehicles and battery technologies.

Wolfgang Maluche graduated from The University of Applied Science in Munich with a Bachelor of Science Degree in Mechanical Engineering and a Master of Science Degree in Engineering from Texas A&M University. He started his career at Audi AG in Ingolstadt, Germany where he held multiple roles in Procurement and Technical Project Management. Wolfgang transitioned to Volkswagen Group of America in 2018 and took over the role of VP of Engineering and the lead of the Engineering Planning Center (EPC) in Chattanooga, TN in 2020.

In his current role as Vice President of Engineering, Wolfgang is managing and coordinating the Engineering teams while serving as a central engineering contact within the US for strategic topics and coordination activities within the VW Group. The Engineering team is supporting Volkswagen Operations in Chattanooga and responsible for the testing of the locally assembled HV Batteries.

PANEL DISCUSSION

PLASTICS AND COMPOSITES IN ELECTRIC VEHICLES

MODERATOR

Dr. Leonardo Simon

Leonardo C. Simon is Professor in the Department of Chemical Engineering at the University of Waterloo, in Canada. He teaches undergraduate and graduate courses in Materials Sciences and Engineering, Polymers, and Nanocomposites. He obtained both his BEng (1995) and MEng (1998) in Chemical Engineering and his PhD (2001) in Materials Science, all from the Federal University of Rio Grande do Sul located in Porto Alegre, Brazil. He joined the University of Waterloo as a faculty member in 2002. His research areas include the synthesis, characterization and properties of polymer materials, nanocomposites and bioproducts. His research group uses nanotechnology, polymer science and engineering to develop new and enhanced plastics and composites for applications in automotive, packaging and consumer goods. In 2018 he created Polynovus Consulting to meet the demand from industrial research collaborators and deliver consulting to companies in the areas of materials and manufacturing, new technology and innovation.

MODERATOR

Christoph Kuhn, Dr.-Ing.

Christoph Kuhn currently supports Volkswagen's introduction of the US produced electric vehicle fleet as the Technical Project Lead - HV Battery in North America. Previous to his position with Volkswagen Group of America, he was a Sr. Project Manager with Volkswagen's Group Research at their headquarters in Wolfsburg, Germany, focusing on functional materials for EV batteries and lightweight solutions. For his role as the project lead in the publicly funded research project "LehoMit-Hybrid", Dr. Kuhn was awarded the JEC Composites Innovation Award in 2020.

Dr. Kuhn holds a PhD in Mechanical Engineering (Dr.-Ing.) from FAU Erlangen-Nuremberg, Germany, a M. Sc. and B.Sc. from RWTH Aachen, Germany and a M.Sc. from the University of Wisconsin-Madison, USA. He has been an active member of the SPE since 2014 and is currently Secretary of SPE Composites Division.

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Be part of the 2nd-Annual **SPE Automotive Plastics in Electric & Autonomous Vehicles Conference** and learn how electric and autonomous vehicle development is driving innovative automotive solutions. This event will feature technical presentations, keynote speakers and panel discusions, networking breakfasts, breaks, lunches and receptions, and exhibits that highlight advances in this fast-growing industry.

Stayed tuned at **EAVConference@speautomotive.com** for more information about this coming years event.

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CALL FOR NOMINATIONS

MOST INNOVATIVE USE OF PLASTICS AWARDS

The Automotive Division of the Society of Plastics Engineers (SPE®) is announcing a "Call for Nominations" for its 51st-annual ***Automotive Innovation Awards Gala,*** the oldest and largest recognition event in the automotive and plastics industries. This year's Awards Gala will be held Wednesday, **NOVEMBER 2, 2022** at the Burton Manor in Livonia, Mich. Winning part nominations **(due by September, 7, 2022)** in 11 different categories, and the teams that developed them, will be honored with a **Most Innovative Use of Plastics** award. A **Grand Award** will be presented to the winning team from all category award winners.

A special category has been added for the 51st-annual Automotive Innovation Awards: **EV and AV Systems,** to recognize innovative polymer components for Electric and Autonomous Vehicles.

SPONSORSHIP OPPORTUNITIES

This annual event currently draws over 800 OEM engineers, automotive and plastics industry executives, and media. A variety of sponsorship packages - including tables at the banquet, networking receptions, advertising in the program book, signage at the event and more are available. Contact Teri Chouinard of Intuit Group at **teri@intuitgroup.com**.

For more info and to submit nominations, go to: **www.speautomotive.com/innovation-awards-gala**

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