19TH ANNUAL

AUTOMOTIVE COMPOSITES CONFERENCE & EXHIBITION

Novi, Michigan • September 4-6, 2019

Presented by SPE Automotive Division and SPE Composites Division

COMPOSITES:
FORMING THE FUTURE OF TRANSPORTATION WORLDWIDE

SEPT 4-6, 2019

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WELCOME TO THE

19th-Annual

AUTOMOTIVE COMPOSITES CONFERENCE & EXHIBITION

Novi, Michigan • September 4-6, 2019

Presented by SPE Automotive Division and SPE Composites Division

Matt Carroll
General Motors Company

Dr. Alper Kiziltas
Ford Motor Company

On behalf of SPE, we'd like to welcome you to the SPE Automotive Composites Conference and Exhibition (ACCE). For the 19th consecutive year, this conference remains the world's leading forum dedicated to automotive composites. Year after year, we attract a global audience of thought leaders who provide the inspiration for our theme. This year's theme is **Composites: Forming the Future of Transportation Worldwide**

We are immersed in a world of light-weighting, smart-connected and electric vehicles which involves both metals and advanced composite materials. Eighteen years ago these were far away dreams. Now these dreams are reality and we have the technology to design, simulate and manufacture vehicles of this caliber. It is a very exciting time for the industry.

A warm thank you to all who contributed to making this year's event bigger and better than years past including our technical authors and presenters, keynote speakers and panelists. Organizing the SPE ACCE requires many contributors. With the enthusiasm and energy of our volunteers, presenters, staff and sponsors we have a full agenda which we are sure you will enjoy.

During the next three days you have the opportunity to grow your network and extend your knowledge of composites from our industry leaders and your peers. Please be sure to visit the exhibits, attend the technical sessions, keynotes and panel discussions and participate in the Student Poster voting. And don't forget to ask questions and have fun!

Kind regards,

Matt Carroll, General Motors Company &
Dr. Alper Kiziltas, Ford Motor Company
2019 SPE ACCE Co-Chairs

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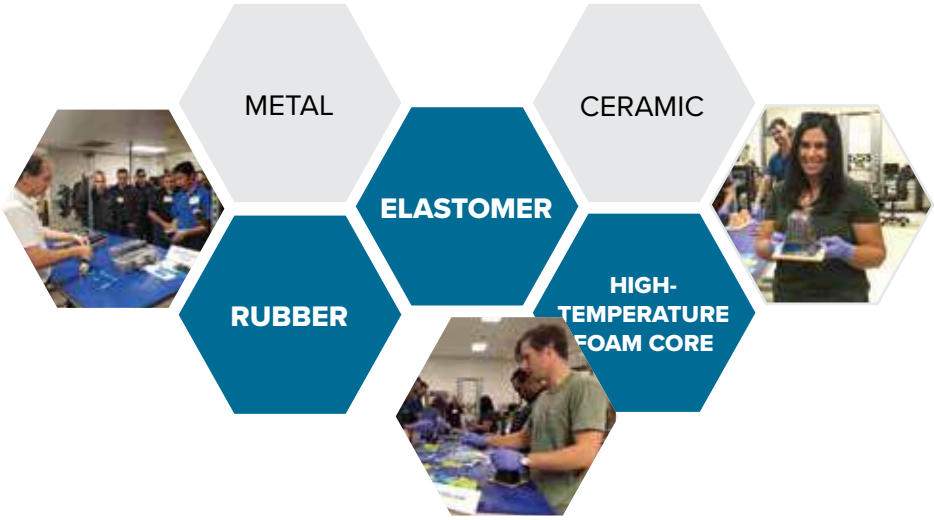

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WEDNESDAY SEPTEMBER 4

AGENDA 2019

EXHIBITS OPEN Wednesday 9:00 a.m. to 4:30 p.m.

7:00–8:00	**REGISTRATION / BREAKFAST - Diamond Ballroom**			
8:00–8:30	**OPENING REMARKS** - Diamond Ballroom Including **Best Paper and Scholarship Awards** **Alper Kiziltas & Matt Carroll,** 2019 SPE ACCE Chairs / **Ian Swentek,** ACCE Awards Chair			
8:30-9:00	**KEYNOTE 1** - Diamond Ballroom **Dr. Cynthia Flanigan,** *Chief Engineer, Vehicle Research & Technology, Ford Motor Co.* **Driving Automotive Materials Forward**			
9:00-10:00	**EXHIBITS OPEN – Hall C (no sessions) & JUDGING FOR STUDENT POSTER COMPETITION**			
	ONYX	**OPAL/GARNET**	**EMERALD/AMETHYST**	**PEARL**
	ADVANCES IN THERMOPLASTIC COMPOSITES - 1/7	**ADVANCES IN THERMOSET COMPOSITES - 1/5**	**ENABLING TECHNOLOGIES - 1/4**	**ADDITIVE MANUFACTURING AND 3D-PRINTING - 1/5**
10:00-10:30	High Performance Glass Fiber Reinforced Polypropylene "Thermylene® P11" for Light Weighting Automotive Components **Vive Apte** *Asahi Kasei Plastics North America Inc.*	PuriCoat System: A Low Emission, Solvent-free Material Platform Enabling High Volume Production of Exterior Composite Parts **Francis Defoor** *Hexion*	**FEATURED TALK** From Composite to Complex Materials – A Paradigm Shift for Vehicle Interiors **Clay Maranville** *Ford Motor Co.*	**FEATURED TALK** Additive Manufacturing to Automotive Manufacturing: The Challenges of Volume Production **Ellen Lee** *Ford Motor Co.*
10:30-11:00	Carbon Fiber Reinforced Polyolefin Body Panels **Megan Shewey** *Ford Motor Co.*	Development of a Class A Lightweight SMC Liftgate for the Volksw agen Atlas **Hendrik Mainka** *Volkswagen Group of America*	Polylactide based Direct-Long Fiber Thermoplastics (D-LFTs) for Automotive Interior Application **Preetam Giri,** *Michigan State University*	Additive Manufacturing of Wood-Based Materials for Composite Applications **Douglas Gardner** *University of Maine*
11:00-11:30	Productivity Advantages of Lightweight Injection Molded Thermoplastics Enabled by 3M Hollow Glass Microspheres **Shannon Bollin** *Ford Motor Co.*	Improving Mechanical Performance of Vinyl Ester and Unsaturated Polyester Carbon Fiber Composites Through Use of a Coupling Agent **Brian Kleinheinz** *BYK USA, Inc.*	Evaluations of Low and Ultra-low Density Sheet Molding Composites Using 3M™ Glass Bubbles **Erik LaBelle** *3M - Advanced Materials Division*	Only a Dream? Plastics for 3D Printing – Easy to Process and Parts Strong Like Injection Molded **Thomas Collet** *LEHVOSS Group*
11:30-12:00	Preliminary Studies on the Effect of Polymeric Film Formers and Cross Linking Chemistries on the Water-Glycol Resistance of PA-Glass Fibre Composites **Nagesh Potluri,** *Michelman*			Generative Design and Fabrication: A One Touch Experience for Additive Manufacturing **Tonya Cole** *Dassault Systemes*
12:00-1:00	**LUNCH - Hall C Sponsored by SAMPE / JUDGING FOR BEST COMPOSITE PARTS**			
	ADVANCES IN THERMOPLASTIC COMPOSITES - 2/7	**ADVANCES IN THERMOSET COMPOSITES - 2/5**	**ENABLING TECHNOLOGIES - 2/4**	**ADDITIVE MANUFACTURING AND 3D-PRINTING - 2/5**
1:00-1:30	**BEST PAPER AWARD** Direct Fiber Model Validation: Orientation Evolution in Simple Shear Flow, **Sara Andrea Simon,** *University of Wisconsin Polymer Engineering Center*	Enabling Electro-Mobility Battery System Serial Production with High-Performance Rapid Cure Epoxy SMC **Pritesh Patel** *Evonik*	Development of a Single Cylinder Polymer Matrix Composite Engine Block **Anthony Coppola** *General Motors Co.*	3D Printing Durable, Lightweight, and Flexible Elastomeric Components for Automotive Applications **Andrew Finkle** *University of Waterloo*
1:30-2:00	Thermoplastic Tape Reinforcements for Cost-efficient Lightweight Automotive Applications **Christoph Kuhn,** *Volkswagen Group*	Advances in Resin Technology for Structural Sheet Molding Compound Formulations **Joseph Amlung,** *Ashland LLC*	Fiberpress – A New Generation of Composite Compression Molding **Louis Kaptur** *Dieffenbacher*	Fiber Aspect Ratio Characterization and Stiffness Prediction in Large-Area, Additive Manufactured, Short-Fiber Composites **Timothy Russel,** *Baylor University*
2:00-2:30	Structural Reinforcement of Nylon Parts with UD Tape Layups **Stanislav Ivanov** *Fraunhofer Project Centre for Composites Research*	Cost Effective Hood Manufacturing by Compression Resin Transfer Molding **Unai Argarate** *Fagor Arrasate*	MoPaHyb - Modular Production Plant for Hybrid High-Performance Composites **Sascha Kilian** *Fraunhofer-Institute for Chemical Technology*	In-Situ Consolidation of Thermoplastic Composites using Automated Fiber Placement **Graham Ostrander,** *Automated Dynamics part of Trelleborg Group*
2:30-3:30	**EXHIBITS - Hall C (no sessions) / BREAK Sponsored by Michelman**			
	ADVANCES IN THERMOPLASTIC COMPOSITES - 3/7	**ADVANCES IN THERMOSET COMPOSITES - 3/5**	**ENABLING TECHNOLOGIES - 3/4**	**ADDITIVE MANUFACTURING AND 3D-PRINTING - 3/5**
3:30-4:00	Stylight: A Cost Efficient Production Solution **Pierre Juan** *INEOS Styrolution*	Phenolic Sheet Molding Compound for New Electric Vehicle Architectures **Ian Swentek** *Hexion*	Fatigue Life Prediction of Injection Molded Short Glass Fiber Reinforced Plastics **Pierre Savoyat,** *e-Xstream engineering*	Fused Filament Fabrication Printing for Accelerated Product Development and Low Volume Series Production **Adam Halsbrand** *Forward Engineering*
4:00-4:30	Viscosity Measurement Technique for Long Fiber Thermoplastic Material **Gleb Meirson** *FPC-Western University*	Epoxy Composites with Short Fibers, Long List of Benefits for Automotive Applications **Philip Farris Jr.** *SolEpoxy, Inc.*	Advanced Modeling and Simulation Technology for Advanced Composites Forming **Tonya Cole** *Dassault Systemes*	Analysis and Experimental Verification of Polymer Melt Nozzle Pressure Drop in Fused Filament Fabrication Additive Manufacturing **Jingdong Chen,** *Baylor University*
4:30	**EXHIBITS CLOSED**			
4:30-5:15	**PANEL DISCUSSION 1** – Diamond Ballroom **Polymer Composites in Automotive Applications, State of the Art and Approval Work Flow** Panelists: **Dennis Chung,** *Honda Research & Development Americas, Inc.* **Drew Geda,** *Senior Materials Engineer, Hyundai-Kia America Technical Center, Inc.* **Umesh Gandhi,** *Executive Scientist, Toyota Research Institute North America TMNA R & D* **Bradley Rogers,** *Materials Engineer, Composites Material Specialist, General Motors*			
5:15-5:30	**RECEPTION SPONSOR ADDRESS** - Diamond Ballroom			
5:30-7:00	**COCKTAIL RECEPTION - Fireside Room sponsored by Hexion**			
7:00	Conference Adjourns for the Day			

THURSDAY SEPTEMBER 5

EXHIBITS OPEN Thursday 10:00 a.m. to 4:45 p.m.

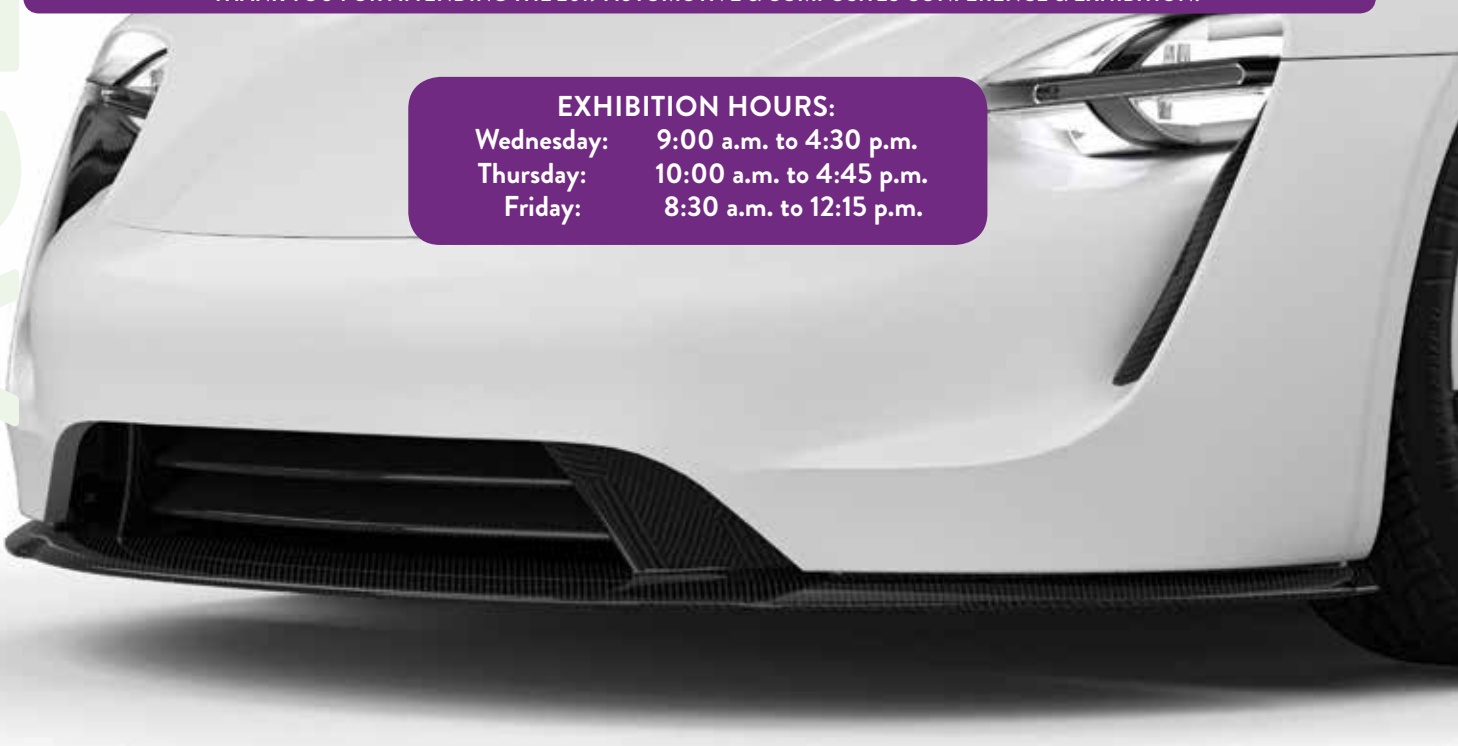
	ONYX	OPAL/GARNET	EMERALD/AMETHYST	PEARL
7:00–8:00	REGISTRATION / BREAKFAST - Diamond Ballroom			
	ADVANCES IN THERMOPLASTIC COMPOSITES - 4/7	ADVANCES IN THERMOSET COMPOSITES - 4/5	SUSTAINABLE COMPOSITES - 1/5	BUSINESS TRENDS AND TECHNOLOGY SOLUTIONS - 1/2
8:00-8:30	Novel In-situ Method for Studying Transfer Films and Tribology Performance of Additives **Rijo Jacob Robin,** *Superior Graphite*	Synthesis & Properties of Several Functional Dimeric Epoxy Resins Containing Naphthalene Units **Mark Edwards,** *Sun Chemical*	**FEATURED TALK** Advances in Sustainable Composites for Automotive Applications **Amar Mohanty,** *University of Guelph*	Advances in Motor Encapsulation **Stephen Greydanus** *Hexion*
8:30-9:00	Additive Manufacturing of Innovative Near Net Shape Continuous Fiber Thermoplastic Composite Preforms **John Ilkka,** *Coats America*	Pushing the Boundaries with Novel Thermoset Polyolefin Composites **Dr. Vishal Shrotriya** *Materia, Inc.*	Developing - Structural Natural fiber Parts using Spray Transfer Molding (STM) Process **Elias Shakour,** *BASF Corp*	Development of Ultra-Light Hybrid Glass Fiber and Polymeric Fiber Reinforced **Hongyu Chen** *Hanwha Azdel*
9:00-9:30	Thermoplastic Pultrusion's Cooling Temperature Effects on Pulling Forces and Deconsolidation **Nawaf Alsinani,** *Universite de Montreal, Polytechnique Montreal*	Case Study: Development of an Epoxy Carbon Fiber Reinforced Roof Frame Using the High Pressure Resin Transfer Molding Process **Cedric Ball,** *Hexion*	Post-Consumer Recycled Based High-Heat PA6,6 Development for Turbocharged Air Intake Ductin **James Kempf** *Wellman Advanced Materials*	Sandwich Construction Provides New Design Solutions for Body Structure & Trim **Russell Elkin** *Baltek Inc.*
9:30-10:30	EXHIBITS OPEN - Hall C (no sessions) / BREAK Sponsored by Asahi Kasei Plastics			
	ADVANCES IN THERMOPLASTIC COMPOSITES - 5/7	ADVANCES IN THERMOSET COMPOSITES - 5/5	SUSTAINABLE COMPOSITES - 2/5	BUSINESS TRENDS AND TECHNOLOGY SOLUTIONS - 2/2
10:30-11:00	One Step Hybrid Molding Process, a Cost Effective Manufacturing Technique for Composite Parts **Pal Swaminathan** *LANXESS*	Innovative Continuous Fiber Preforms for Liquid Thermoset Resin Processes Incorporating Conductive Pathways **George Han** *Coats America*	**3RD PLACE BEST PAPER** Latest Breakthroughs with Hybrid Reinforced Composites in Lightweight Applications **Author: Dinesha Ganesarajan** **Presented by: Leonardo Simon** *University of Waterloo*	Structural Validation of Material Model and CAE Method Accounting for Sheet Molding Compound (SMC) Process **Pierre Savoyat** *e-Xstream engineering*
11:00-11:30	Fibre Direct Compounding - Efficient Fibre Reinforcement at Reduced Material Costs **Manuel Woehrle** *ARBURG, Inc.*	Mechanical Characterization and Constitutive Modeling of a Snap Cure Neat Epoxy Resin Under Dynamic Loading **Yu Zeng,** *University of Waterloo*	Characterization of Hybrid Composite Based on Kenaf and Glass Fibers for Underbody Shield Applications **Sandeep Tamrakar** *Ford Motor Co.*	Plant Based Composite Materials for Automotive: They Exist and are Ready for Prime Time **Mark Remmert** *Green Dot Bioplastics Inc.*
11:30-12:30	LUNCH - Hall C Sponsored by Lotte Advanced Materials / JUDGING FOR BEST COMPOSITE PARTS			
12:30-1:15	EXHIBITS OPEN- Hall C (no sessions) & JUDGING FOR STUDENT POSTER COMPETITION			
	ADVANCES IN THERMOPLASTIC COMPOSITES - 6/7	OPPORTUNITIES AND CHALLENGES WITH CARBON COMPOSITES - 1/4	ENABLING TECHNOLOGIES - 4/4	BONDING, JOINING AND FINISHING - 1/1
1:15-1:45	Simulation of Warpage and Mold Flow in the LFT-D Process **Gleb Meirson** *FPC-Western University*	Design and Simulation of Non-Crimp Carbon Fiber/Epoxy Channels for Energy Absorbing Applications **Pravin Gopal Samy Dharmara** *University of Waterloo*	Development of Modified Polypropylene (PP) Products with Low-Odor for Automotive Interior Parts **Alex Zhou** *Wellman Advanced Materials*	Plasma Surface Engineering of Fiber Reinforced Composites for the Removal of Contaminants and Improvement of Adhesive Joint Strength **Daphne Pappas,** *Plasmatreat USA, Inc*
1:45-2:15	Accelerating Adoption of Advanced Materials into Automotive Through Industry Collaboration **Adam Harms,** *Ruhl Strategic Partners*	Energy Absorption Mechanisms in Impacted Non-Crimp Fabric Carbon Fiber Reinforced Epoxy Composites **Aaditya Suratkar** *Western University*	Does a Fiber Reinforced Thermoplastic Door Structure Meet the Energy Absorption Requirements for a Side Impact Crash Test? **Srikanth Pilla,** *Clemson University*	Primerless Structural Adhesives for Bonding Low Surface Energy Composites **Michael Barker** *Ashland, LLC*
2:15-2:45	Nanofiller-Reinforced Thermoplastic Hybrid Composites **Ezatollah Amini,** *University of Maine*		Mold-Shutter and Double-Deck Frame Systems Improve the State-of-the-Art HP-RTM, LCM, and Prepreg Compression Molding Technologies **Antonio Cossolo,** *Cannon USA*	Composite Sandwich Repair Using Through-Thickness Reinforcement with Robotic Hand Micro-Drilling **Alex Kravchenko** *Old Dominion University*
2:45-3:45	EXHIBITS -Hall C			
	ADVANCES IN THERMOPLASTIC COMPOSITES - 7/7	OPPORTUNITIES AND CHALLENGES WITH CARBON COMPOSITES - 2/4	SUSTAINABLE COMPOSITES - 3/5	REINFORCEMENT TECHNOLOGIES - 1/1
3:45-4:15	Effect of the Die Shape on the Maximum Pultrusion Speed of Natural-Fiber-Thermoplastic Composite **Mahdi Mejri,** *Polytechnique Montreal*	Development of Flowable Carbon Fiber Materials **Selina Zhao** *General Motors Co.*	Methodology to Use PCR (Post-consumer Recycled) Polyamide Material as an Alternative Solution to Prime Polyamide in Automotive Applications **Taehwan Kim** *Wellman Advanced Materials*	Hybrid Composites for Automotive Applications – Development and Manufacture of a System-Integrated Lightweight Floor Structure in Multi-Material Design **Tobias Link,** *Fraunhofer-Institute for Chemical Technology*
4:15-4:45	Nano-Enhanced Polyamide Biocomposites with Improved Dimensional Stability for Automotive Applications **Mohamed Abdelwahab,** *University of Guelph*	Automated Cutting & Stacking Cell for Dry Fiber Textile Reinforcements (GF/CF) in Automotive and Aerospace Applications **Christian Fais** *Schmidt & Heinzmann North America Inc.*	Quality Controls of Post-Consumer Recycled Carpet-Based Resins for the Automotive Industry **Donald Wingard** *Wellman Advanced Materials*	Rheological Behavior of Basalt and Hemp Fiber Reinforced Thermoplastic Composites **Bharath Nagaraja** *Washington State University*
4:45	EXHIBITS CLOSED			
4:45-5:15	**KEYNOTE 2** - Diamond Ballroom **Gulay Serhatkulu,** *Senior Vice President, Performance Materials North America, BASF Corp.,* **Chemistry-Driven Composite Innovation - The Future is Now**			
5:15-5:30	**RECEPTION SPONSOR ADDRESS** - Diamond Ballroom			
5:30-7:00	COCKTAIL RECEPTION - Fireside Room sponsored by Owens Corning			
7:00	Conference Adjourns for the Day			

FRIDAY SEPTEMBER 6

AGENDA 2019

EXHIBITS OPEN Friday 8:30 a.m. to 12:15 p.m.

7:00–8:00	REGISTRATION / BREAKFAST - Diamond Ballroom			
8:00–8:30	**KEYNOTE 3** - Diamond Ballroom **Ed Moss,** Engineering Group Manager, Corvette Body Structures,General Motors **Composites on the New Chevrolet Corvette**			
	ONYX	**OPAL/GARNET**	**EMERALD/AMETHYST**	**PEARL**
	VIRTUAL PROTOTYPING, TESTING AND MODELING - 1/2	**OPPORTUNITIES AND CHALLENGES WITH CARBON COMPOSITES - 3/4**	**SUSTAINABLE COMPOSITES - 4/5**	**ADDITIVE MANUFACTURING AND 3D-PRINTING - 4/5**
8:30-9:00	Fatigue Characteristics of a Random Carbon Fiber SMC-R Composite **Monish Urapakam Ramakrishnan** *University of Michigan, Dearborn*	**FEATURED TALK** Suitability of Carbon Fiber Composites in a High-Volume Production Process for Vehicle Front Subframes **John Ingram,** *Magna International, Inc.*	Investigation of Variations in Closed Cell Foamed Polymer Composite Structures **Daniel Pulipati** *Baylor University*	Multi-Scale Modeling of Additive Manufacturing: From Process Simulation to Design Validation **Dustin Souza** *e-Xstream engineering*
9:00-9:30	CAE Chain-based Optimization Strategies for Fiber Reinforced Composites Parts as a Key Element for Future Lightweight Design **Benedikt Fengler** *SIMUTENCE*	Carbon Fiber Subframe Development – Corrosion Mitigation Strategies and Test Results **David Wagner** *Ford Motor Co.*	Food Industry Waste-Derived Biocarbon and Biobased Engineering Thermoplastic for Sustainable Composite Applications **Maisyn Picard** *University of Guelph, Bioproducts Discovery and Development Centre*	Effects of Flow-Fiber Coupling on Melt Flow Rheology in Large Area Polymer Composite Additive Manufacturing **Zhaogui Wang** *Baylor University*
9:30-10:30	EXHIBITS - Hall C (no sessions) / BREAK Sponsored by **Kruger Biomaterials and Plastiques Moore**			
	VIRTUAL PROTOTYPING, TESTING AND MODELING - 2/2	**OPPORTUNITIES AND CHALLENGES WITH CARBON COMPOSITES - 4/4**	**SUSTAINABLE COMPOSITES - 5/5**	**ADDITIVE MANUFACTURING AND 3D-PRINTING - 5/5**
10:30-11:00	Modeling Morphology and Physical Properties of Nanocomposites Using Molecular Simulation **Jeffrey Sanders** *Schrodinger, Inc.*	**2ND PLACE BEST PAPER** Carbon Fiber Subframe Development – Fatigue and Strength CAE and Test Results **Xiaoming Chen** *Ford Motor Co.*	Development of Sustainable Hybrid Composites Using Recycled Polypropylene and Engineered Polysaccharide **Sea Ho Jeon** *Wellman Advanced Materials*	Topology Optimization for Lightweighting Anisotropic Additively Manufactured Parts Under Thermomechanical Loading **Jackson Ramsey** *Baylor University*
11:00-11:30	Composites Forming: Advanced Modeling & Simulation **Tonya Cole** *Dassault Systemes*	Carbon Fiber Subframe Design and CAE **Nikhil Bolar** *Magna International, Inc.*	Improved Utilization of Downstream Corn Oil from Bioethanol Industry: Super Performed Sustainable Flame Retardant for Engineering Plastic-Based Biocomposites in Automotive Applications **Boon Chang,** *University of Guelph*	Sustainable Biocomposites from Biobased Engineering Thermoplastic and Biocarbon through Additive Manufacturing **Elizabeth Diederichs** *University of Guelph*
11:30-12:15	LUNCH - Diamond Ballroom Sponsored by **Faurecia**			
12:15	EXHIBITS CLOSED			
12:15-1:00	**PANEL DISCUSSION 2** - Diamond Ballroom **What We Can Learn from Other Industries** Panelists: **To Be Announcd**			
1:00-1:30	**STUDENT POSTER COMPETITION WINNERS:** Uday Vaidya			
1:30-2:00	**PART INNOVATION AWARDS and CLOSING REMARKS:** Alper Kiziltas and Matt Carroll, 2019 SPE ACCE Chairs			
	THANK YOU FOR ATTENDING THE 2019 AUTOMOTIVE & COMPOSITES CONFERENCE & EXHIBITION!			



EXHIBITION HOURS:

Wednesday:	9:00 a.m. to 4:30 p.m.
Thursday:	10:00 a.m. to 4:45 p.m.
Friday:	8:30 a.m. to 12:15 p.m.

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CONFERENCE CO-CHAIR
Matt Carroll, General Motors Co.
matt.carroll@gm.com
+1.586.218.9405
ACCE-chair@speautomotive.com

CONFERENCE CO-CHAIR
Dr. Alper Kiziltas, Ford Motor Co.
akizilt1@ford.com
+1.207.249.5948
ACCE-chair@speautomotive.com

TECHNICAL PROGRAM CO-CHAIR
Dr. David Jack, Baylor University
david_jack@baylor.edu
+1.254.710.3347

TECHNICAL PROGRAM CO-CHAIR
Dr. Leonardo Simon
University of Waterloo
leonardo.simon@uwaterloo.ca
+1.519.888.4567 x33301

PROGRAM TREASURER
Bonnie Bennyhoff
SPE Automotive Div.
treasurer@speautomotive.com
+1.248.244.8993 ext. 4

SPONSORSHIP CHAIR
Teri Chouinard, Intuit Group
teri@intuitgroup.com
+1.248.701.8003

PROGRAM ADMINISTRATOR
Kim Hoodin,
SPE Automotive Div.
accepapers@speautomotive.com
+1.513-582.2442

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REGISTRATION
Scott Marko, SPE International
smarko@4spe.org
+1.203.740.5442
ACCE-registration@
speautomotive.com

STUDENT POSTER COMPETITION CHAIR
Uday Vaidya
University of Tennessee-Knoxville
uvaidya@utk.edu
+1. 205.410.2898

Proceedings Guide & Signage Design:
Jill Houser, JPI Creative Group
Signage Printing:
Suzanne Lee, That Color
Printing:
PrintComm
Plaques & Trophies:
Sponsored by SPE. Awards supplied by Maples Ad Specialties

2019 SESSION ORGANIZERS

ADDITIVE MANUFACTURING & 3D PRINTING

Steven VanLoozen, Chair
Celanese
vanloozens@gmail.com
+1.734.218.3054

Umesh Gandhi
Toyota Technical Institute NA
umesh.gandhi@toyota.com
+1.734.995.7174

ADVANCES IN REINFORCEMENT TECHNOLOGIES

Bhavesh Shah
General Motors
bhavesh.shah@gm.com
+1.586.907.2866

Steve Bassetti
Michelman, Inc.
stevebassetti@michelman.com
+1.513.794.4195

Dr. Ö. Özgü Özsoy
Ford Otomotiv Sanayi A.S.
oozsoy1@ford.com.tr

ADVANCES IN THERMOPLASTIC COMPOSITES

Steve Bassetti
Michelman, Inc.
stevebassetti@michelman.com
+1.513.794.4195

Victor Bravo
Compuplast
victor_brave2002@yahoo.com
+1.647.302.4669

Robert Egbers
Mytex Polymers
bob_egebers@mytexpolymers.com
+1.248.912.8154

Raghu Panduranga
North Carolina A&T State University
raghupanduranga@gmail.com
+1.336.210.9353

Santosh Sarang
Aisin Technical Center of America
ssarang@aisintca.com
+1.734.582.7608

ADVANCES IN THERMOSET COMPOSITES

Dustin Davis, Chair
Norplex-Micarta
DDavis@norplex-micarta.com
+1.317.498.0149

Dan Dowdall
Ashland Inc.
djdowdall@ashland.com
+1.248.755.2674

Enamul Haque
haqueenamul007@gmail.com
+1.401.834.5144

Santosh Sarang
Aisin Technical Center of America
ssarang@aisintca.com
+1.734.582.7608

Yuyang Song
Toyota Research Institute, NA
yuyang.song@toyota.com

Bhavesh Shah
General Motors
bhavesh.shah@gm.com
+1.586.907.2866

Dale Brosius
IACMI
dbrosius@iacmi.org
+1.586.530.3372

BONDING, JOINING AND FINISHING

Enamul Haque
haqueenamul007@gmail.com
+1.401.834.5144

Michael J. Barker
Ashland, Inc.
mjbarker@ashland.com
+1.614.790.5398

BUSINESS TRENDS AND TECHNOLOGY SOLUTIONS

Paula Kruger, Chair
DSM Engineering Plastics, Inc
paula.kruger@dsm.com
+1.248.979.6128

Suresh Shah
Delphi Corp., Retired
sbshah356@gmail.com
+1.248.635.2482

ENABLING TECHNOLOGIES

Victor Bravo
Compuplast
victor_brave2002@yahoo.com
+1.647-302-4669

Peter McCormack
Proper Group International
petermccormack@mnsi.net
+1.519.990.7460

OPPORTUNITIES AND CHALLENGES WITH CARBON COMPOSITES

Dale Brosius, Chair
IACMI
dbrosius@iacmi.org
+1.586.530.3372

Glade Gunther
Solvay
Glade.Gunther@solvay.com
+1.435.730.4477

Nippani Rao
RAO Associates
nippanirao@aol.com
+1.248.444.1753

Ray Boeman
Michigan State University
boemanrg@msu.edu

Jim deVries
JdV Lightweight Strategies, LLC
Jim.devries@jdvlws.com

SUSTAINABLE COMPOSITES

Dan Houston
Ford Motor Co., Retired
housto79@msu.edu
+1.313.204.4941

Mehdi Tajvidi
University of Maine
mehdi.tajvidi@maine.edu
+1.207.581.2852

Esra Erbas Kiziltas
Wellman
esra.kiziltas@wellmaner.com
+1.207.249.5948

VIRTUAL PROTOTYPING AND TESTING

Pete Foss
General Motors, retired
petefoss@skymasters.org
+1.248.807.4288

Antoine Rios
The Madison Group
antoine@madisongroup.com
+1.608.231.1907

Doug Smith
Baylor University
Douglas_E_Smith@baylor.edu

AD HOC COMMITTEE

Dale Brosius
Chair Emeritus
IACMI
dbrosius@iacmi.org
+1.586.530.3372

Fred Deans
Allied Composite Technologies LLC
fdeans@alliedcomptech.com
+1.248.760.7717

Bonnie Bennyhoff
ExxonMobil, retired
treasurer@speautomotive.com
734.660.3200

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ABSTRACTS 2019

WEDNESDAY SEPT 4

KEYNOTE 1 -

Driving Automotive Materials Forward

Dr. Cynthia Flanigan, Chief Engineer, Vehicle Research & Technology, Ford Motor Co.

The growth of the auto industry, current policy frameworks and R&D efforts encourage the use of cost-effective, lightweight, sustainable and advanced materials for automotive applications. Ford scientists continue to pioneer the development of sustainable and advanced materials including nanocomposites, aerogels, natural fiber reinforced composites, polymeric and soft materials made from renewable feed stocks, 3-D printed plastic parts, bio-inspired and patterned functional materials as well as plastic parts made from recycled carbon dioxide, which meet stringent automotive requirements.

ONYX ROOM

ADVANCES IN THERMOPLASTIC COMPOSITES – 1/7

High Performance Glass Fiber Reinforced Polypropylene "Thermylene® P11" for Lightweighting Automotive Components

Vive Apte, Asahi Kasei Plastics North America Inc.

The use of Glass Fiber Reinforced PP in Automotive Components continues to increase due to their favorable strength/impact balance and lower specific cost compared to engineering thermoplastics. Traditionally higher mechanical properties were obtained for these materials at the expense of melt flow rate or processability. Asahi Kasei Plastics has recently developed Thermylene® P11 family of PP-GF materials, offering higher tensile strength at room temperature and elevated temperatures along with improved creep and fatigue resistance and high flow. This novel property balance is expected to enable OEMs and Tier suppliers to fine tune the necessary performance without worrying about any compromise. These are targeted for glass fiber reinforced PA6 and PA66 as well as Long Glass PP replacement.

Carbon Fiber Reinforced Polyolefin Body Panels

Megan Shewey, Ford Motor Co.

Carbon fiber reinforced plastics offer excellent specific stiffness. When derived from reclaimed/recycled carbon fiber (rCF) compounded with inexpensive polyolefins (PO) for injection molding, they have the potential to meet both performance and affordability targets for lightweight, paintable automotive body panels. This project investigates utilizing rCF compounded with special formulations of POs to produce automotive exterior body panels that have the potential to meet requirements for fit, finish, mechanical performance, and paintability while offering significant mass savings over incumbent metal panels and cost savings versus other composite solutions.

Productivity Advantages of Lightweight Injection Molded Thermoplastics Enabled by 3M Hollow Glass Microspheres

Shannon Bollin, Ford Motor Co.

Andrea C. Charif, 3M Advanced Materials Division

Glass microspheres from 3M can offer multiple advantages in injection molded plastics, including lightweighting, processing improvement, and dimensional stability. In this study, formulations with glass microspheres were created to meet the specifications of existing materials and determine the effect on cycle time, processing conditions, mechanical properties, and warpage using a research tool developed by Ford Research containing pressure and temperature transducers. Both polypropylene and polyamide formulations were evaluated from multiple material suppliers, and savings and improvements were found in both cycle time and processing conditions with mechanical properties meeting existing specifications.

Preliminary Studies on the Effect of Polymeric Film Formers and Cross Linking Chemistries on the Water-Glycol Resistance of PA-Glass Fibre Composites

Nagesh Potluri, Michelman

Strict emission regulations and fuel-economy standards have increased performance demands on glass fiber reinforced thermoplastic composites used in automotive applications. Because under-the-hood components perform in extreme temperature and fluid environments, there is an effort to implement standards that require these types of automotive components to retain up to 80% of their mechanical properties after soaking for 3,000 hours in a glycol-water. This presentation offers an overview of various sizing chemistries and a discussion regarding the structure-function relationship between sizing chemistries and glycolysis resistance properties. Michelman explored several new polymeric film formers and novel cross-linking chemistries with the primary goal of improving water-glycolysis resistance. This exploration included E-glass filaments applied with a sizing formulation consisting of 1-2 film formers/

cross-linking agents, 3-Aminoprpylethoxy Silane, and a surfactant. The assembled glass rovings and PA 66 were compounded and subsequently injection molded into test specimens and aged for 400 hours in ethylene glycol/water (1:1) at a temperature of 135o C. Data, including tensile strength, interfacial properties, and composite failure modes will be reviewed.

ADVANCES IN THERMOPLASTIC COMPOSITES – 2/7

BEST PAPER AWARD

Direct Fiber Model Validation: Orientation Evolution in Simple Shear Flow

Sara Andrea Simon,
Polymer Engineering Center

Predictive tools for fiber properties such as orientation, concentration and length have become indispensable for the automotive industry. Current commercially implemented models require experimentally determined fitting parameters, which can be time consuming and expensive to obtain. Particle-level simulations obtain fitting parameters numerically. To ensure that the proposed multi-particle model for reinforcing fillers is able to accurately reproduce fiber orientation evolution, reinforced Polypropylene compression molded samples were subjected to a simple shear flow in a Sliding Plate Rheometer. The fully characterized microstructure of the compression molded plates was used to reproduce the initial conditions in the multi-particle simulation. It was found that the model has good agreement with the final orientation state, however the model shows faster orientation evolution at the start of the shearing process.

Thermoplastic Tape Reinforcements for Cost-Efficient Lightweight Automotive Applications

Christoph Kuhn, Volkswagen Group

Advanced lightweight materials are a necessity to satisfy the need for efficient and safe vehicles in the face of future transportation scenarios like shared mobility and electric drives. A versatile, cost-efficient way to produce safe, lightweight components is the use of local fiber reinforcements in multi-material injection molding. With the example of a Porsche center tunnel, it is shown that the combination of unidirectional tape reinforcement, metal inserts and injection molding can lead to significant weight reductions in automotive body structure while maintaining structural integrity. Before manufacturing, a tape layup is generated by automated fiber placement based on the structural requirements and loading cases of the component. The different layers are further consolidated in a novel vacuum assisted heater into a single plate. During manufacturing, the plate is heated in an infrared heater, transferred into a mold and draped into a complex tunnel shape by the closing mold halves. Inside the closed mold, the material and the previously inserted metal parts are overmolded with thermoplastic melt into a single multi-material component. Conclusively, a lightweight center tunnel can me manufactured in a cost-efficient single shot process, which is further evaluated in full-scale vehicle testing.

Structural Reinforcement of Nylon Parts with UD Tape Layups

Stanislav Ivanov, Fraunhofer Project Centre for Composites Research

Long fiber thermoplastic materials for injection molding (LFT) offer improved mechanical properties comparing to neat or short fiber reinforced resins. It is a challenge in injection molding to preserve fiber length while processing the materials from a feed throat to a hot runner – breakage may result in more than 60% fiber length reduction. Thus, LFT still underperforms materials with continuous fibers and fabrics by a large margin. A solution is to use continuous fiber reinforcements of unidirectional (UD) tapes in co-molding with LFT. UD tapes can be laid up in a required laminate configuration giving a product designer a control over fiber orientation, reinforcements can be done locally on the part thus significantly reducing added costs of UD tapes, and tapes and laminates can be pre-formed into 3D shapes in a one step in injection molding. PolyOne Corporation and its Polystrand division have developed UD glass tapes with nylon-6 resin. Layup configurations were tested at Fraunhofer Project Centre for Composites Research in a one-shot injection molding process on Krauss Maffei 1600 MX machine. Mechanical tests proved the materials showed good formability without wrinkling and can be effectively applied for reinforcing complex geometries. Also, a good bonding between UD tape and polymer matrix reduced a risk of a failure at the interface.

ADVANCES IN THERMOPLASTIC COMPOSITES – 3/7

Stylight: A Cost Efficient Production Solution

Pierre Juan, INEOS Styrolution

Introduced in 2016, the new SAN based thermoplastic composite StyLight® convinces with structural stiffness and a unique surface quality close to Class A, directly from the mold. Two years later, as processing and part design limits were identified during the development of the initial demonstrator, INEOS Styrolution decided to continue the investigation of StyLight® using different processing technologies, mold designs and surface decoration to investigate the new material limits and develop solutions for customers interested to develop and industrialize StyLight® applications. INEOS Styrolution will present a cost-efficient way of producing an aesthetic carbon composite interior automotive part which meets all major automotive standards. The interaction of ARRK Shapers´ specially developed mold concept and StyLight® resulted in a cost reduction of up to 50% compared to the thermoset version. Focus will be placed on the design of the mold concept for the production of an automotive center console part made of the carbon thermoplastic composite StyLight®. Other aspects discussed are StyLight´s advantageous properties as well as the compression and backmolding processes of StyLight®.

ABSTRACTS 2019

Viscosity Measurement Technique for Long Fiber Thermoplastic Material

Gleb Meirson, FPC-Western University

Long Fiber Thermoplastic-Direct (LFT-D) is getting traction with the automotive industry as a cost-effective lightweight structural components manufacturing method. This paper presents an extensive study on the effects of part geometry and molding conditions. Screw rotation speeds, charge placement, and reinforcement using continuous fiber tapes and organosheets were used. Several techniques such as plasma, IR heat, and adhesives were used in this study in attempts to enhance the adhesion of the LFT-D material to the reinforcement and the resulting bonds were examined. In addition, localized reinforcement of an LFT-D charge with a glass mat thermoplastic (GMT) material was investigated.

OPAL/GARNET ROOM

ADVANCES IN THERMOSET COMPOSITES – 1/5

PuriCoat System: A Low Emission, Solvent-Free Material Platform Enabling High Volume Production of Exterior Composite Parts

Francis Defoor, Hexion

Today, visible composite parts are mainly produced using prepreg or resin transfer molding (RTM). However, the production of complex-shaped parts using prepregs is cumbersome because of their limited drapeability. In addition, the fabrication of the pre-impregnated intermediates adds an expensive process step. In contrast, RTM is an attractive alternative that provides greater design freedom, as well as higher build rates thanks to shorter cycle times. However, there is normally a trade-off between surface quality and RTM cycle times due to the so-called fiber print-through effect. This phenomenon is caused by the construction of the used reinforcements and mismatch between the thermal expansion coefficients of the resin and fiber; showing up during the cool-down of molded parts. The effect can be minimized by applying relatively low RTM operating temperatures – 80-90°C – and through additional surface treatment and coating steps. But the consequences of this approach are lower productivity and higher cost. To overcome these limitations, a new in-mold coating approach is introduced.

Development of a Class A lightweight SMC Liftgate for the Volkswagen Atlas

Hendrik Mainka,
Volkswagen Group of America

Lightweight construction is an integral part of Volkswagen's overall strategy of reducing CO_2 emissions. Due to its low cost, steel is the most commonly used material for automotive exterior body panels today. Unfortunately, steel has a high density, resulting in a relatively low specific strength. Glass fiber-based sheet molding compound (SMC) provides high properties in combination with lower density. The high specific strength of SMC offers an enormous lightweight potential. In comparison to steel, a mass reduction for the Volkswagen Atlas liftgate of up to 35% is expected, without a degradation of the functionalities. Volkswagen Group of America worked on this project with IACMI (Institute for Advanced Composites Manufacturing Innovation), University of Tennessee Knoxville, Purdue University and Michigan State University, Ashland, IDI, Owens Corning and Continental Structural Plastics. This paper will highlight the major steps in the development process on the way to technology readiness for SMC using the example of the Volkswagen Atlas Liftgate. The result is an e-coat capable Class-A SMC liftgate, which is ready for high volume production.

Improving Mechanical Performance of Vinyl Ester and Unsaturated Polyester Carbon Fiber Composites Through Use of a Coupling Agent

Brian Kleinheinz, BYK USA, Inc.

While epoxies account for the majority of the carbon fiber reinforced plastic (CFRP) composite market, vinyl esters and unsaturated polyesters can offer many benefits for certain applications, including improved flow behavior, adjustment of curing kinetics and corrosion resistance, among others. The mechanical properties of these composites are directly related to the adhesive strength between the resin matrix and carbon reinforcement. In this presentation, we discuss the usage of a new coupling agent that enhances this adhesive strength between vinyl ester or unsaturated polyester and carbon fiber. Improvement in mechanical strength (flexural and transverse to the fiber) is shown in CFRP parts, and we discuss how this improvement allows for greater design freedom, whether in achieving higher performance with these resin chemistries or in part weight-reduction. Furthermore, we demonstrate that this coupling agent can be added at any stage of production of the composite, whether added directly to the liquid resin, or applied to the dry carbon fiber as a new technology, "Second Sizing".

In-Mold Dielectric Analysis During Cure of a Polyurethane-based Sheet Molding Compound

Sergej Ilinzeer, Fraunhofer Institute for Chemical Technology

The application of polyurethane resin systems in sheet molding compound (SMC) promises potential benefits in regards to mechanical performance and recyclability of parts. However, the high reactivity of conventional polyurethane systems renders them unsuitable in such applications. In this work, a novel polyurethane system based on blocked crosslinkers is used to produce SMC parts. An in-mold dielectric sensor was used to measure the dielectric response of the material during cure in dependence of various process parameters.

ADVANCES IN THERMOSET COMPOSITES – 2/5

Enabling Electro-Mobility Battery System Serial Production with High-Performance Rapid Cure Epoxy SMC

Steffen Kanzler, Evonik

Electro-mobility growth in the automotive sector requires new solutions for drivetrain and energy storage systems. In particular, battery system requirements are stringent due to safety and lightweight considerations. Next generation designs, advanced materials and enabling process technologies are needed. Compression molded styrenic sheet molding compounds (SMC) are already used in the manufacture of complex battery case geometries alongside aluminum and steel materials. Epoxy resin-based SMC can reduce the weight by up to 30% and will even increase the range of suitable applications within the automotive sector beyond battery systems due to cost effective, high-performance characteristics. Within the framework of a consortium project, the potential of Epoxy resin with Vestalite S hardener chemistry from Evonik Industries AG to use for SMC-based battery cases for electro-mobility vehicles is introduced. Comprehensive concept development demonstrates the advantages of Epoxy SMC performance, processing and functional integration compared to state-of-the-art aluminum and standard SMC solutions. Important items such as flame resistance, thermal management, integration of Engineering Electrical/Electronic architecture and the technical connection to the car structure is reviewed.

Advances in Resin Technology for Structural Sheet Molding Compound Formulations

Joseph Amlung, Ashland LLC

For almost a half century, sheet molding composites (SMC) have been utilized for exterior and semi-structural applications by the automotive industry. As the industry is now rapidly changing, SMC technologies must also change and grow to meet new challenges. Applications such as EV battery-enclosure and pickup-truck stowage-systems require significant advances in material strengths, mass savings, and flame retardancy. Ashland Composites has developed a new series of cost-effective thermoset resin systems to provide a solution to these challenges. The resin matrix has high mechanical properties and can accommodate a wide range of reinforcements, additives, and fillers to meet specific performance requirements. This presentation will outline these advances and benefits and discuss potential applications for their use.

Cost Effective Hood Manufacturing by Compression Resin Transfer Molding

Unai Argarate, Fagor Arrasate

Reduction of $C0_2$ emissions in transportation is highly dependent on lightweighting measures, as novel drive trains and energy storage methods penalize car weight. The use of carbon fibre reinforced polymers (CFRP) in cars and commercial vehicles is one of the most appropriate solutions, reducing weight by up to 70% and dissipating impact energy at a rate 5 times greater than that of metals. One of the most promising alternatives to reduce fill times and increase the fiber content of CFRP is the Compression Resin Transfer Moulding (CRTM) process, allowing for shorter injection times, shorter reaction time and faster turnaround on the moulds. The result is increased efficiency enabling OEMs to integrate CFRP parts into lower price segmented cars, increasing the efficiency of standard transportation and helping reach emission goals of the future. Fagor Arrasate has designed customized lines for OEMs and Tier1s, offering fast and cost-effective manufacturing of carbon fiber parts. Fagor Arrasate and Riba Composites, with Alpex and research centers FHNW and MGEP, has manufactured a demonstrator bonnet of a Maserati car with air Intakes and internal ribs built using this technology.

ADVANCES IN THERMOSET COMPOSITES – 3/5

Phenolic Sheet Molding Compound for New Electric Vehicle Architectures

Ian Swentek, Hexion

Phenolic resins that meet REACH compliance and contain low free-formaldehyde are safe to handle, compound, and mold. These resin systems do not contain any styrene or require any fillers to achieve their rated fire resistance. A commercial phenolic sheet-molding compound (SMC) is presented that achieves a 2-minute cycle time and addresses the unique requirements in an electrified vehicle architecture. This new SMC material includes all the industrially relevant considerations including material processing, shelf life, and surface finish. Other topics such as material hybridization and comparison to incumbent materials also discussed.

Epoxy Composites with Short Fibers are Long on Benefits for Automotive Applications

Philip Farris Jr., SolEpoxy, Inc.

The automotive industry is no stranger to the use of polymers and composites in underhood applications. Some non-metallic materials currently being used in automotive applications include fiber reinforced nylon, polyphthalamide, polyamide-imide, and polyester in the form of BMC or SMC. One significant use of these composites is to reduce weight and maximize fuel efficiency. Engine components have proven the most difficult

to convert from metal, due to the strenuous conditions of heat, temperature cycles and engine fluids the materials must be able to withstand. Fiberglass has been used for decades to strengthen plastics such as nylon, PPA, PAI, and polyester. Carbon fiber, once a high-end specialty, is now finding its way into more mainstream applications. We propose to add another material to this list of common automotive composites, fiber reinforced epoxy. Epoxies offer additional advantages in processing efficiency that may allow composite technology to break into consumer-level automotive manufacturing. In this paper, we will explore the properties of some epoxy molding compounds reinforced with carbon fibers and compare them with existing composite alternatives.

EMERALD/ AMETHYST ROOM

ENABLING TECHNOLOGIES - 1/4

FEATURED TALK:

From Composite to Complex Materials – A Paradigm Shift for Vehicle Interiors

Clay Maranville, Ford Motor Co.

Much work has gone into developing advanced polymer materials for vehicle interior applications in the past several decades at all points in the value chain. This work has been primarily focused on ensuring that the materials, and the components made from them, meet the attribute targets established by engineers and designers. In this talk, we will explore why material systems have evolved to the point they have today, and how Human-Centered Design principles and disruptions to the automotive industry are changing how and why materials engineers may need to rethink their approaches to materials development and discovery in the future. This disruptive paradigm shift will affect how materials engineers and chemists will need to compete in a world obsessed with squeezing every efficiency possible from the rush to connectivity, mobility, big data, AI, ubiquitous sensing, IOT and blockchain.

Polylactide based Direct-Long Fiber Thermoplastics (D-LFTs) for Automotive Interior Applications

Preetam Giri, Michigan State University

Despite its commercial acceptance in low-end single-use plastic applications, PLA has not been considered a viable material-of-choice for applications requiring durability and high structural strength. This work primarily focuses on the use of basalt and glass fibers to reinforce the PLA matrix for automotive interior applications. The PLA-based fiber composite materials were produced by adopting the Direct-Long Fiber Thermoplastic (D-LFT) approach, wherein continuous rovings of the fibers were directly fed into a twin-screw extruder. The D-LFT technique allows for a higher aspect ratio of the fiber in the matrix leading to improved load transfer at the fiber-matrix interface. Optimization of the process parameters, including screw configuration, was performed to ensure desired level of fiber breakage and dispersion, and to maximize the fiber content in the final composite material. PLA-based short fiber composites were prepared under similar processing conditions to demonstrate the efficacy of the D-LFT technique at preparing composite samples with a higher aspect ratio and improved mechanical performance over using short fiber. Proof-of-concept for manufacturing hybrid composite materials through the existing setup using two different fiber rovings was established by feeding continuous rovings of basalt and glass fiber simultaneously. Mechanical properties of the composite samples including tensile, impact fracture, and dynamic mechanical behavior were studied. Morphology of the fracture surfaces of the tested specimens were obtained using SEM.

Evaluations of Low and Ultra-low Density Sheet Molding Composites Using 3M™ Glass Bubbles

Erik LaBelle, 3M - Advanced Materials Division

There is a continuous trend to reduce the specific gravity (SG) and final part weight of Automotive Sheet Molding Composites (SMC). The use of high-strength hollow glass microspheres is one technology to enable lower density SMCs. In this study, low (1.2 g/cc) and ultra-low (1.0 g/cc) density sheet molding composites (SMC) were prepared using glass bubbles in laboratory scale SMC equipment. The mechanical properties were evaluated against standard density (1.9 g/cc) and mid density (1.5 g/cc) SMC samples. The distribution of glass bubbles and glass fibers in the composites were examined using a scanning electron microscope. The rheological properties as a function of adding glass bubbles into the A-side paste will also be presented.

ENABLING TECHNOLOGIES - 2/4

Development of a Single Cylinder Polymer Matrix Composite Engine Block

Anthony Coppola, General Motors

Over the proceeding decades, polymer-based materials have become increasingly crucial to modern automobile design due to their high strength and stiffness to weight ratios, ability to be manufactured into complex geometries, corrosion resistance, and acoustic damping. However, metals remain the dominant material in internal combustion engines (ICE) partially due to the hot temperatures developed. In this study, we designed and fabricated a single cylinder polymer matrix composite (PMC) intensive engine block utilizing unique design features to address the thermal challenge. The engine block was then tested for over 100 h of durability testing as a component of an operating engine. Results demonstrate normal function of the engine throughout testing with the PMC block, significant reduction in temperature using vascular cooling, and significant reduction in noise transmission.

Fiberpress – A New Generation of Composite Compression Molding

Louis Kaptur, Dieffenbacher

Fiberpress is a new style of vertical press offered by Dieffenbacher, based on decades of experience designing hydraulic presses and complementing composite technologies. Utilizing an intelligent short stroke system, the press saves significant energy compared to conventional long stroke systems. Per part and yearly energy savings will be shown for typical composite molding materials. The mechanical design of the press structure ensures the mold is stressed evenly, resulting in uniform component thickness. Precise parallelism control ensures smooth guiding of the ram during mold closing and opening, improving the overall machine and mold lifetime. Additionally, the compact design minimizes floor space and building height required at a production facility. A new advanced control system and visualization offers intuitive operation, exact adaptation of process parameters, and process data acquisition

MoPaHyb - Modular Production Plant for Hybrid High-Performance Composites

Sascha Kilian, Fraunhofer ICT

Hybrid components based on a multi-material approach are one of the most promising lightweight technologies for structural applications. However, current lot sizes, part derivatization and plant investment costs for individual products inhibit economic feasibility and thus transfer to series application. Within the MoPaHyb project fourteen partners developed a modular and reconfigurable production plant generation allowing easy adaptation to produce a wide spectrum of individual hybrid components also taking into account economical target. The key is a plug & work architecture that connects production modules to a base control unit. The engineering language AML and the communication interface OPC UA with unified status models are used as standardized communication channels. A reference production plant including the cutting-edge technologies tape placement, press forming, long fiber injection molding as well as metal working, laser treatment and insert provision was set up to demonstrate the new plant generation. The concept has been validated by means of two different demonstrator parts and several hundred produced parts, also taking into account modular safety aspects and integrated quality assurance.

ENABLING TECHNOLOGIES - 3/4

Fatigue Life Prediction of Injection Molded Short Glass Fiber Reinforced Plastics

Pierre Savoyat, e-Xstream engineering

This work will present a framework that combines experimental and numerical efforts to predict fatigue life of SFRP parts. This includes characterization of the failure mechanisms on simple injection molded (IM) tensile bars, the use of samples milled from IM plaques to study anisotropy, and different test geometries to include multiple stress states. The effect of load ratio is considered for all samples and is accounted for in the final approach. Finally, a lifetime stress gradient dependency is identified and deployed to correct finite element analysis (FEA) lifetime prediction. Subsequently, the resulting models are applied on an in-house designed IM demonstrator part, where the predicted and corrected lifetime is compared with experimental results.

Advanced Modeling and Simulation Technology for Advanced Composites Forming

Tonya Cole, Dassault Systémes
Alireza Forghani and
Paulo Silva, Convergent

Many industries, including aerospace, automotive, and energy, are facing multiple challenges related to the design and manufacturing of composite components. As parts become more complex and materials continue to advance, new automated manufacturing methods have been developed. While the automation of these new processes helps reduce variation and overall production cycle time, they can be difficult to accurately simulate. Dassault Systémes and Convergent Manufacturing Technologies have teamed up to develop an integrated workflow that allows designers and manufacturing engineers to simulate the composite forming process with disruptive, yet scalable software technologies. This presentation will highlight some of the current industry challenges related to manufacturing complex composite parts, showcase advanced modelling, and simulation tools dedicated to the forming manufacturing process, and provide a deep dive into the integrated workflow using Convergent's software technologies and the CATIA Composites Forming solution.

PEARL ROOM

ADDITIVE MANUFACTURING AND 3D-PRINTING - 1/5

FEATURED TALK:

Additive Manufacturing to Automotive Manufacturing: The Challenges of Volume Production

Ellen Lee, Ford Motor Co.

Additive manufacturing technologies have long been used in the automotive industry for prototypes of new vehicle designs and for engineering validation. As AM processes and material technologies continue to advance, we are able to use AM parts for more functional, load bearing applications including tooling and fixtures to enhance our manufacturing efficiencies. But can additive manufacturing deliver on the promise of volume production for automotive applications? Automotive industry

needs differ significantly from those of aerospace, medical, and consumer industries in terms of performance and durability, as well as cycle time and annual volumes. Learn how additive manufacturing can create value in various ways for the automotive sector in production end-use applications; key challenges in the validation and implementation processes; and the future outlook for volume production using additive manufacturing technologies.

Additive Manufacturing of Wood-Based Materials for Composite Applications

Douglas Gardner, University of Maine

Wood-based material components including sawdust, wood flour, bamboo, lignin, and cellulose nanofibers are being explored as functional additive reinforcements in thermoplastic and thermosetting matrices used in additive manufacturing (AM) or 3D printing. The 3D printing processes most typically reported using wood-based materials include the extrusion-based fused filament fabrication, fused deposition modeling, and pellet-fed large-scale AM, selective laser sintering, and liquid deposition modeling. The rationale for using wood-based components in 3D printing include enhancing the material properties of resulting printed parts such as increased mechanical properties, reduced dimensional instability, i.e. part warpage, improved aesthetics, providing a green alternative to carbon or glass filled polymer matrices, as well as reducing material costs. This presentation will provide an overview of wood-based material applications in 3D printing for composites with a state-of-the-art review of current research activities around the world.

Only a Dream? Plastics for 3D Printing – Easy to Process and Parts Strong Like Injection Molded

Thomas Collet, LEHVOSS Group

The LEHVOSS Group is offering thermoplastic materials specially designed and optimized for industrial 3D printing. Those materials provide a performance that enables parts quality similar to injection molded parts. This is due to bespoke materials, derived from a long experience in composites, and the fact that the respective 3D printing technologies, including specific printers, and final products are considered. The existing and ready to use materials cover the requirements of many automotive applications for serial applications. Additionally, customized materials could be formulated to meet the requirements of the specific application, including the structural, conductive, shielding, high temperature and tribological performance.

Generative Design & Fabrication: An Inclusive Experience to Accelerate Innovation

Tonya Cole, Dassault Systémes
Kishore Boyalakuntla, Rize Inc.

The new-age Digital Engineer is now empowered to design, simulate and fabricate an industrial additive manufactured part, all in one environment. The utilization of generative design for additive manufacturing allows designers to create parts intended for a specific purpose, designed to specification. By unifying design, simulation and manufacturing in one environment, we remove bottlenecks that prevent this process from becoming scalable. With the access and addition of a printer in the design process, engineers can now fully experience what it takes to efficiently create and iterate upon new innovative designs that were previously unimaginable by linking the digital world to real life applications. Join Dassault Systémes and Rize Inc to learn how you can use generative design and additive manufacturing in one seamless experience to create designs never before possible, streamline design and production and scale the technology across your company to accelerate product innovation through better integration between design, engineering, manufacturing and service.

ADDITIVE MANUFACTURING AND 3D-PRINTING - 2/5

3D Printing Durable, Lightweight, and Flexible Elastomeric Components for Automotive Applications

Andrew Finkle, University of Waterloo

Lightweight materials are a critical mid- to long-term strategy for automotive manufacturers around the world. Reduced vehicle weight leads to reduced fuel usage, improved safety, and lower vehicle costs, adding value for customers and reducing emissions-related environmental impacts. To meet emissions standards and remain competitive, automotive manufacturers require advances in manufacturing processes at a fast pace. The advent of additive manufacturing has important implications for prototyping, small-scale inventory replacement, and custom tooling; however, these practices are still at the very early stages of evaluation. The presented research will address a technology gap identified by large companies that are currently engaged with 3D printing technology - dealing with the lack of capacity for 3D printing with soft materials. The presentation will investigate novel design and synthesis of silicone elastomer parts via additive manufacturing using Structur3d Printing's Discov3ry Complete 3D Printer for viscous materials. This research will unite the development of materials, equipment, and models to enable additive manufacturing with low-density soft materials, thus accelerating the implementation of lightweight materials.

Fiber Aspect Ratio Characterization and Stiffness Prediction in Large-Area, Additive Manufactured, Short-Fiber Composites

Timothy Russell, Baylor University

Previously, the authors of this study developed a methodology for predicting the fiber orientation state and effective elastic modulus of a short-fiber, polymer composite bar fabricated using large-area additive manufacturing (LAAM). The predictions were made for a 13 wt% carbon fiber reinforced acrylonitrile butadiene styrene (ABS) and checked by tensile testing samples made using an in-house LAAM machine. Predicting the internal fiber orientation state of the sample and the elastic modulus (a function of the orientation state) requires knowledge of the fiber aspect ratio. Previously, the fiber aspect ratio was chosen arbitrarily, albeit within reason. In this study, we sought to experimentally characterize it and update our predictions and experiments. We found and present both the weighted average and the number average of the fiber aspect ratio of the 13 wt% carbon fiber ABS both before and after the material has been processed in the LAAM machine. We then use these aspect ratio values to make predictions of the fiber orientation state and the resulting elastic modulus of a tensile bar.

In-Situ Consolidation of Thermoplastic Composites using Automated Fiber Placement

Graham Ostrander, Automated Dynamics part of Trelleborg Group

In-situ consolidation (ISC) with automated fiber placement (AFP) of thermoplastic composites (TPC) is a fully automated and true additive manufacturing process. Recent developments in prepreg tapes, laser heating, equipment, and process control have demonstrated the ability to manufacture autoclave quality structures with ISC. A key challenge facing manufacturers is addressing throughput speeds to achieve desired production rates. The ability to co-bond thermoplastic stiffeners with ISC eliminates the need for secondary operations traditionally required to fasten stiffeners to skins. This paper reviews worldwide efforts to develop ISC, Automated Dynamics current capability to manufacture autoclave quality structures using ISC, and future work needed to meet throughput targets. Automated Dynamics' current state of the AFP work cell uses a closed loop Laser Heating System to melt bond the incoming thermoplastic material to the previous ply at a high rate of speed. The resulting structure has autoclave equivalent consolidation and porosity. This paper surveys the capabilities of Automated Dynamics current state-of-the-art in-situ automated fiber placement work cell for processing autoclave quality thermoplastic composites structures via a true OoA process.

ADDITIVE MANUFACTURING AND 3D-PRINTING - 3/5

Fused Filament Fabrication Printing for Accelerated Product Development and Low Volume Series Production

Adam Halsbrand, Forward Engineering

New materials and manufacturing technologies for 3D-printed plastic parts enable new uses for this technology. Material makers offer new advanced materials, which are optimized for usage in FFF (Fused Filament Fabrication) or SLS (Selective Laser Sintering) technology, leading to at least equivalent mechanical behavior of 3D-printed plastic parts in comparison to common injection molded materials and allowing faster process times and a bigger variety of usable reinforcement materials. 3D-printed parts for structural thermoplastic applications can be used to reduce cost and time for prototyping and testing during the product development processes for conventional injection molded parts by identifying the right materials which are process equivalent to the developed injection molded part. First projects are showing the potential of 3D-printed parts in the development process, lowering cost and decreasing needed times for prototype tooling and testing. Another possibility is the use of 3D-printed parts for small series production and high-performance thermoplastic parts, taking advantage of given design freedom due to less limiting manufacturing guidelines by 3D-printing. With increased know-how about manufacturing and material, lifecycle calculations become feasible. Understanding and redefining structural needs will be key for further investments in 3D-printing.

Analysis and Experimental Verification of Polymer Melt Nozzle Pressure Drop in Fused Filament Fabrication Additive Manufacturing

Jingdong Chen, Baylor University

Quantifying nozzle pressure drop in Fused Filament Fabrication (FFF) polymer melt flow can be used to understand the effect of nozzle geometry and polymer melt rheology on the deposition process. Existing pressure drop models focus on various sections within the FFF nozzle which includes both conical and cylindrical flow geometries having regions of shear and extensional flow. Unfortunately, little attention has been given to the validation of various FFF nozzle flow models for predicting the pressure drop through the nozzle prior to material deposition. Our study develops a custom filament force measuring device that is used to obtain the pressure drop through commercially available FFF nozzles. The measured pressure drop is then compared to computed results obtained using various FFF nozzle flow models that incorporate various polymer melt rheology models including the Power Law, Cross, Carreau, and Carreau-Yasuda models. We also examine a model that included an extensional flow component that has been proposed in the literature. Our computed results show that the FFF nozzle has the highest pressure drop in the conical

contraction and capillary regions, and that polymer melt flow in the inlet cylinder cannot be ignored. These computations are then used to assess the relative accuracy of various FFF nozzle melt flow models.

THURSDAY SEPT 5

KEYNOTE 2 -

Chemistry-Driven Composite Innovation - The Future is Now

Gulay Serhatkulu, *Senior Vice President, Performance Materials North America, BASF Corp.,*

The increased desire for stronger, lighter, more sustainable material solutions can only be achieved with new chemistries together with creative product designs. This presentation will outline the challenges facing composites solutions in the automotive industry and what needs to happen to increase the adoption. Examples from BASF will be highlighted, explaining how they are using chemistry to drive composites innovation now and in the future by implementing a different way of working, bringing the company offering new chemistries and the part designer closer than ever before.

ONYX ROOM

ADVANCES IN THERMOPLASTIC COMPOSITES – 4/7

Resilient Graphitic Carbon for Wear and Friction Modification

Rijo Jacob Robin, Superior Graphite

This paper will discuss electro-thermal purification technology, graphite and RGC (Resilient Graphitic Carbon), tribological characterization in PEEK and comparing performance of different graphite type under varying pressure and velocity conditions, thermal conductivity and different graphite type thermal conductivity using Netzsch flash technique, Resilient Grades in polymer applications, and EU Food contact approval with some successful applications.

Additive Manufacturing of Innovative Near Net Shape Continuous Fiber Thermoplastic Composite Preforms

John Ilkka, Coats America

The OEM's business case in material selection for structural applications continues to focus on the balance between cost and weight savings. Continuous fiber thermoplastic composites in the form of UD tapes, organosheet, and 3D preforms have a cost issue due to the non-value added steps associated in manufacturing the preforms – weaving of the textile reinforcement, direct labor to cut and stack, and the waste associated with not using 25 – 65% of material. Recently, the preform process has been automated, but the other cost elements remain and the associated capital can be prohibitive. Coats developed an additive manufacturing process to produce near net shape continuous fiber thermoplastic preforms directly from roving/tow commingled with thermoplastic fibers that eliminates these non-value added steps. The result is a very cost-effective weight saving solution. Coats, in collaboration with the University of Alabama in Birmingham, has conducted studies on the use of Synergex™ (commingled fibers) and Lattice™ (preform). This paper will review the process for engineering and designing the preforms and the resulting mechanical properties of the molded thermoplastic continuous fiber preforms.

Thermoplastic Pultrusion's Cooling Temperature Effects on Pulling Forces and Deconsolidation

Nawaf Alsinani, Universite de Montreal, Polytechnique Montreal

Surface finish defects and deconsolidation have slowed the commercial use of thermoplastic pultruded products. We have developed an efficient cooling system that is able to accurately control the cooling temperature profile. The aim of this study was to investigate the effects of varying cooling die temperatures on the pulling forces and the deconsolidation behaviour in thermoplastic pultrusion. Carbon/PEI pultruded rods of 4.76 mm in diameter were produced using a multi-die pultrusion system. The fiber volume content of the rods was 56%. Adhesion forces in the cooling die were measured using pulling force data collected by a load-cell in the pultrusion line. The selected cooling temperatures were Tg/2, and Tg and (Tg+Tp)/2. Deconsolidation and surface finish quality were characterized using microscopy and surface roughness measurement. High pulling forces were observed when cooling was raised to and higher. Deconsolidation and higher void content were also observed when the cooling temperature was higher than. The proposed state-of-the-art cooling system will create significant new opportunities for the use of thermoplastic pultruded products in many fields.

ADVANCES IN THERMOPLASTIC COMPOSITES – 5/7

One Step Hybrid Molding Process, a Cost Effective Manufacturing Technique for Composite Parts

Pal Swaminathan, LANXESS

As a result of more stringent requirements on fuel economy, the automotive industry is in constant search for new materials and technologies that offer lightweight solutions to replace heavier materials such as steel and aluminum, often demanding new manufacturing processes. The challenge is to use, as much as possible, the existing manufacturing process with the ability to meet the high production volume requirements for the automotive industry. LANXESS has developed Tepex®, a thermoplastic composite sheet based on materials such as polyamide and continuous reinforcement like glass, carbon or aramid fibers. Due to its endless-fiber reinforcement, strong mechanical properties are achieved, paving the way for thermoplastics in highly-loaded, structural applications. Tepex® composite sheets can be used in combination with injection-molded Durethan® polyamide to make parts in a one-step, hybrid molding process. The final product is lightweight with strong mechanical properties and is less expensive due to the possibility for functional integration of attachments and other surrounding parts, as well as reduction in secondary operations such as welding or bonding.

Fibre Direct Compounding - Efficient Fibre Reinforcement at Reduced Material Costs

Manuel Woehrle, ARBURG, Inc.

Long fibre reinforced materials are used more and more in substitution of materials and therefore lightweighting of parts. With an inline compounding process - Fibre Direct Compounding (FDC) - on an injection moulding machine, it is possible to realize high volume production of long fibre parts at reduced parts costs. Beside reducing of material costs, longer fibres in the part improve mechanical properties of the parts, substitution is easier, there is flexible material choice and high material availability. In this presentation the process and the benefits of this process are explained, examples and potentials are highlighted, and an outlook of the combination of FDC with composite sheets is given.

ADVANCES IN THERMOPLASTIC COMPOSITES – 6/7

Simulation of Warpage and Mold Flow in the LFT-D Process

Gleb Meirson, FPC-Western University

The Long Fiber Thermoplastic-Direct (LFT-D) process is attracting increasing interest in the automotive industry as a cost-effective light-weight manufacturing method for structural components. This paper presents an extensive study of molding three different geometries using the LFT-D process and comparing the results to compression molding simulations done using Moldex3D. Simulation results such as: force buildup, force-temperature dependence and flow pattern, were compared with experimental measurements. In addition, the predictions of warpage in the parts using Moldex3D were compared with actual measurements

Accelerating Adoption of Advanced Materials into Automotive Through Industry Collaboration

Adam Harms, Ruhl Strategic Partners

Overcoming the barriers of adoption of advanced materials onto a vehicle can be overwhelming, especially for materials which are not yet mainstream in the industry. Over the past decade, many in the industry have failed to break through, unable to gain any real substantive adoption into the value chain. As no single company can provide a complete solution, we must realize it takes a collective team of industry partners centered (and motivated) around providing a full solution to the market, making it easier for the OEMs to say yes. A case study for market adoption will be presented, where through industry collaboration, a full solution of materials, process, and technology partners have come together to provide a commercial on-ramp, validating and demonstrating production of direct-from-mold Class A thermoplastic parts to both OEMs and Tiers. This innovative solution is currently disrupting, and may potentially be replacing, the traditional paint process for molded plastic parts. This industry collaborative model serves as a scalable approach from which to increase the adoption of advanced composite materials.

Nanofiller-Reinforced Thermoplastic Hybrid Composites

Ezatollah Amini, University of Maine

During the selective laser sintering (SLS) process, a tremendous amount of residual powder is generated. Processing the powder residue into filaments for additive manufacturing or using that as a polymer matrix for composite applications can provide an opportunity to advantageously recycle SLS residue. In this study, recycled polyamide 12 (rPA12) from SLS process was utilized as a thermoplastic polymer matrix for composite production. RPA12 powder residue first extruded into filaments and the filaments were then mixed with reduced carbon fibers (rCF) to formulate the basic composite (masterbatch). Basic composites were loaded with 0.1, 0.5, and 1% nanofillers, including cellulose nanocrystals (CNC), graphene nanoplatelets (GNP), and reduced graphene oxide (rGO). Compared to the basic composites (rCF/rPA12), addition of nanofillers in most cases showed to enhance tensile and flexural properties of the hybrid composites. However, impact strength did not change or in some cases even decreased by adding nanofillers.

ABSTRACTS 2019

ADVANCES IN THERMOPLASTIC COMPOSITES – 7/7

Effect of the Die Shape on the Maximum Pultrusion Speed of Natural-fiber-thermoplastic Composite

Mahdi Mejri, Polytechnique Montreal

The automotive industry aims at reducing the use of plastic materials, usually made from oil exploitation. Eco-friendly materials, such as the natural-fiber-reinforced thermoplastic composites, are great candidates to reach this objective. However, the blending process of natural fibers in a thermoplastic matrix is challenging in terms of impregnation and production rate. Few manufacturing procedures can provide simultaneously intimate mixing of fibers into the thermoplastic matrix and production volumes needed by the automotive industry. A multi-die vacuum assisted pultrusion was developed to potentially solve both challenges containing a preheater to heat up the yarns without melting the polymer, four dies heated beyond the melting temperature to enhance the impregnation and a cooling die to avoid the deconsolidation of composite rods. This manufacturing procedure has been used to produce flax/polypropylene (PP) rods with good reinforcement distribution and low voids content. Subsequently, the obtained specimens were pelletized and injection-molded in dog bone coupons. This demonstrates that the technology can be used to produce precursors for the automotive industry. However, a high pultrusion speed could not be reached with flax fibers. It is suspected that pultrusion die shape generated too high friction/viscous forces that caused flax fiber breakage. The aim of this study is to investigate the effect of pultrusion die shape on the pultrusion loads, impregnation quality and maximum process speed without breakage. Linear taper, characterized by a conical surface followed by a cylinder, has been investigated in this study. The first results have shown that the lower taper angle allows an increase in pultrusion speed, while keeping a high impregnation quality and low pultrusion forces.

Nano-Enhanced Polyamide Biocomposites with Improved Dimensional Stability for Automotive Applications

Mohamed A. Abdelwahab, University of Guelph

The coefficient of linear thermal expansion (CLTE) of new polymeric biocomposites should be controlled and engineered appropriately to adapt to the existing large-scale processing equipment for real world auto-part applications. The difference in CLTE value resulted in dimensional variation in the composite material due to thermal stresses. Incorporation of fillers to polyamide 6 (PA6) has received much attention, particularly in automotive applications owing to low cost of the final product as well as decreased CLTE value. Nanoclay attracts great research interest in the polymer nanocomposite field as it requires a small amount of addition to enhance the mechanical and thermal properties of the sample. The incorporation of nanoclay into PA6 resulted in a significant decreased CLTE value of the resulting nano-biocomposites. In our research, melt extrusion followed by injection molding was used in fabricating composites from biocarbon and nanoclay hybrid reinforcement with PA6. Biocarbon was produced by the pyrolysis of biomass in the absence of oxygen. Anisotropic morphology and crystalline structure of the biocomposites displayed optimum mechanical properties along with improved dimensional stability.

OPAL/GARNET ROOM

ADVANCES IN THERMOSET COMPOSITES - 4/5

Synthesis & Properties of Several Functional Dimeric Epoxy Resins Containing Naphthalene Units

Mark Edwards, Sun Chemical

In recent years, there has been substantial development of high-performance epoxy resins which offer improvements in both processing and physical properties for various composites. In this study, we synthesized some kinds of dimeric naphthols and their epoxies derivatives and evaluated their cured resin properties. Two kinds of naphthols, 2,7-dihydroxynaphthalene (2,7-DHN) and 2-hydroxy naphthalene (2-HN) were reacted with formaldehyde to produce dimeric naphthols. By changing the ratio of these raw materials, we could control the functionalities of the dimeric naphthols. The epoxy resins derivatives were prepared by the reaction of the corresponding dimeric naphthol with epichlorohydrin. Herein we report the behavior of the cured with diaminodiphenyl sulfone (4,4'-DDS). In our evaluation, two functional dimeric naphthol epoxy has excellent high modulus, high Tg with low water absorption. When this epoxy resin combined with LER (liquid Bisphenol-A epoxy resin), showed good mechanical properties suitable for composite application.

Pushing the Boundaries with Novel Thermoset Polyolefin Composites

Dr. Vishal Shrotriya, Materia, Inc.

Thermoset Polyolefins made by ring-opening metathesis polymerization (ROMP) are known for high toughness, low water absorption, and excellent resistance to chemicals. Despite a promising price-performance profile, applications of poly-dicyclopentadiene (pDCPD), which is the most commonly known thermoset polyolefin, have been limited in part by the sensitivity of the curative catalysts, restricting their use to unreinforced systems processed by reaction injection molding. Recent advances in ruthenium-based catalyst curatives that are more robust and highly tunable has allowed new advances in processability and compatibility with various composite fillers and reinforcements. As a result, a new family of thermoset polyolefin resins now offer a broad range of thermo-mechanical properties like impact toughness, elongation, Tg and chemical resistance, and fit with various processing techniques including

mold casting, infusion (RTM, VARTM), pultrusion, filament winding and rotomolding. This presentation will outline recent advances in thermoset polyolefin based advanced composites with emphasis on automotive applications. Key benefits including fast infusion, short cycle time, lightweight, high impact toughness, and wider manufacturing tolerances make Proxima thermoset polyolefins an ideal candidate for automotive applications.

Case Study: Development of an Epoxy Carbon FIber Reinforced Roof Frame Using the High Pressure Resin Transfer Molding Process

Cedric Ball, Hexion

Increasing knowledge of composite design, simulation tools, new materials and process equipment are all contributing to make composites better performing and more affordable for mass-produced vehicles. In particular, the high-pressure resin transfer molding (HP-RTM) process is enabling manufacturers to produce complex composite parts at shorter and shorter cycle times. This presentation will describe the development of an epoxy carbon fiber roof frame targeted for future vehicle production. Special consideration is taken to evaluate several composite processes for the roof frame fabrication. Meeting all OEM performance requirements and economic targets, the resulting carbon fiber part weighs 60% less than the original design in magnesium. The part was the first HP-RTM part successfully demonstrated in North America and stands as a model for future lightweighting developments. The case illustrates that successful combination of (product) design, material and process can yield an efficient and competitive product. In this case the development process for the part involved a unique collaboration of several companies, each contributing their particular expertise to the project including resin, reinforcement, engineering analysis, process simulation, tool construction, preforms and molding. The collaboration enhanced the speed and technical success of the overall development.

ADVANCES IN THERMOSET COMPOSITES - 5/5

Innovative Continuous Fiber Preforms for Liquid Thermoset Resin Processes Incorporating Conductive Pathways

George Han, Coats America

Haibin Ning, University of Alabama Birmingham Materials Processing and Applications Development (MPAD) Center and Department of Materials Science and Engineering

Marc Philippe Toitgans, Continental Structural Plastics - Europe

Automotive OEMs continue to seek integration of parts and functions to add value for their customers by decreasing cost and adding functionality. Current automotive composite solutions focus on maximizing weight savings while minimizing cost and typically do not focus on functionality. Inevitably, our metallic competitors are focused on the same strategies and we end up in a never-ending competitive trap. Adding value by adding functionality will allow composites to differentiate our solutions. Coats has developed an additive manufacturing process to produce dry fiber preforms directly from roving/tow that eliminates the weaving, cutting, stacking, and waste associated with existing preform technologies. The dry fiber preforms can be molded using HP-RTM and LCM thermoset resin processes. In the same additive manufacturing process we can simultaneously incorporate conductive pathways. The result is a very cost-effective weight saving solution that allows the OEM to incorporate the functions of wire harnesses and autonomous vehicle sensors directly into the composite. The process for engineering and designing the preforms and the resulting mechanical properties of the thermoset resin molded continuous fiber conductive preforms (Lattice™ Conductive) will be reviewed.

Mechanical Characterization and Constitutive Modeling of a Snap Cure Neat Epoxy Resin Under Dynamic Loading

Yu Zeng, University of Waterloo

Owing to their potential energy absorption capabilities, continuous fiber-reinforced plastic (FRP) composites are considered for use in automotive structures subjected to impact loading, where understanding the inherent loading rate-dependent mechanical properties is essential to predict structural performance. The rate-dependent behavior of the polymer matrix will tend to dominate the rate-dependent response of FRP composites containing brittle fibers, so it is important to quantify this effect for crash applications. This study investigated the tensile properties of a three-part snap curing resin system formulated for rapid resin transfer molding processes over a range of strain rates (10–4 to 102 –1). The experimental results revealed that both the tensile modulus and strength of the resin increased with increasing applied strain rates. The samples exhibited limited ductile behavior at low strain rates, while a brittle response was observed at higher strain rates. Power-law and Johnson-Cook elastic-plastic models were investigated to predict the strain rate dependency of the tested material in Abaqus. Overall, the Johnson-Cook model provided an improved fit to the experimental data when compared to the power-law model.

ABSTRACTS 2019

OPPORTUNITIES AND CHALLENGES WITH CARBON COMPOSITES - 1/4

Design and Simulation of Non-crimp Carbon Fiber/ Epoxy Channels for Energy Absorbing Applications

Pravin Gopal Samy Dharmaraj,
University of Waterloo

Owing to high specific properties, carbon fiber-reinforced plastics (CFRP) may be suitable alternatives for replacing metallic components in front-end automotive structures. In this study, a numerical simulation approach is used to investigate the response of unidirectional non-crimp CFRP laminated crush rails under dynamic impact conditions. Straight CFRP channels used as main front structural components are likely to fail progressively by splaying or widespread fragmentation, including local matrix cracking and fiber breakage, which comprise their main energy absorption mechanisms. The specific energy absorption capabilities of four CFRP channels with variable cross-sections are compared, while the simulation results are used to optimize their design for improving crashworthiness and enhancing CFRP utilization. Specific energy absorption was also predicted for two different stacking sequences, including [0/±45/90]s and [±45/0/0]s, where the latter proved to yield higher energy absorption. The results of the study are important for the development of future vehicle CFRP front lower rails.

Energy Absorption Mechanisms in Impacted Non-Crimp Fabric Carbon Fiber Reinforced Epoxy Composites

Aaditya Suratkar, Western University

Energy absorption mechanisms in uni-directional heavy tow (50K) non-crimp fabric carbon fiber reinforced epoxy composites subject to impact loads are investigated in this study. The materials were manufactured using High Pressure-Resin Transfer Molding (HP-RTM) process. Stacking schedules of [0]7, [0]11 (unidirectional lay-ups), [0/±45/90]s (quasi-isotropic lay-up) and [±45/02]s (multi-directional lay-up) were impacted upon by a cylindrical tup with a hemispherical end with varying impact energies (20J, 45J, 80J, 120J, 150J). A rebound was observed at low impact energies (20 J and 45J), whereas the impactor perforated completely through the UD test coupons at 80 J and through the quasi-isotropic and multi-directional lay-ups only at a higher impact energy of 150 J. Micro-CT was employed to identify the extent of damage with increasing impact energies, nature of damage and distinguishing failure modes such as delamination, fiber breakage, matrix cracking and microcracking. The CT-scan images also revealed growth of distinct dominant failure modes in different stacking sequences as the impact energies were increased. An assessment of contributions of these fracture characteristics to the work of fracture is performed in this study.

OPPORTUNITIES AND CHALLENGES WITH CARBON COMPOSITES - 2/4

Development of Flowable Carbon Fiber Materials

Selina Zhao, General Motors

Reducing the fabrication cost is a major step towards reducing the final piece cost for carbon fiber reinforced polymer composite products. In this report we introduce a new family of carbon fiber composites that is flowable and moldable similar to short fiber composites. However, the molded panels have properties at par with hand-layup carbon fiber composites, achieved by perforating unidirectional carbon fiber prepregs to a predetermined fiber length distribution using a perforating machine designed and built to produce the desired product. Furthermore, a lightweight flowable core material was formulated and produced to be used in a sandwich structure along with the flowable carbon fiber prepreg as the face sheets. Using these materials, 12x12 inch plaques were molded and tested for mechanical and physical properties. Also, structural beams were molded and tested in the three-point flex mode for performance confirmation. The results show that this family of carbon fiber composites can enable net shape molding with fast cycle times of less than 3 min without, for the most part, scrap or offal. Furthermore, the low-pressure molding capability of these materials enable the use of low-cost tooling, which, specifically at low volumes, enhances resultant cost savings.

Automated Cutting & Stacking Cell for Dry Fiber Textile Reinforcements (GF/CF) in Automotive and Aerospace Applications

Christian Fais, Schmidt & Heinzmann North America Inc.

The presentation will outline the latest innovative machine technology, which is setting new standards in automatic stacking of dry fiber textile reinforcements (GF/CF) in automotive and aerospace applications. In an automatic stacking application the key aspects are process stability, narrow tolerances for weight and shape, and the economical production. Unique characteristics are: high quality single ply cutting without vacuum table and process auxiliaries like vacuum film and cutting paper, integrated nesting software for minimum material cut-off, high precision stacking with minimum tolerances due to direct interfaces between cutting table and stacking robot, flexible gripper technology for multi-contour ply handling, and automated labeling and ultrasonic welding of stacks. The customized and material specific process can be programmed comfortably via a line control system including a simulation-based and process pre-engineered system in Virtual Reality.

EMERALD/ AMETHYST ROOM

SUSTAINABLE COMPOSITES - 1/5

FEATURED TALK

Advances in Sustainable Composites for Automotive Applications

Amar Mohanty, University of Guelph

"Climate change is a science-based fact". World needs to move quickly towards a de-carbonized economy through renewable and sustainable resources. We have a finite amount of resources and with the growing population a new look at solid waste management is required. A circular economy approach to better resource utilization requires re-engineering our materials from bio-resources, wastes, recycled materials and their combinations. Composite materials are perfectly positioned for this challenge and we already have significant advances in developing the next generation of sustainable composites. Auto-makers see strong promise in such light-weight and eco-friendly composites. Natural fiber composites, known as biocomposites, started in 1908 followed by innovation in glass fiber composites in 1940 and a year after, Henry Ford made a foot print by demonstrating soy-based biocomposites for auto-parts. Hybrid composites, that combine petro- and bio-resources, are also making marked advances in manufacturing. Some of the major scientific challenges to developing composite materials with industrial co-products and waste plastics (including recycled fibers) are improved fiber-matrix adhesion in engineering high performance sustainable composites. Researchers at the Bioproducts Discovery and Development Centre (BDDC), at the University of Guelph, are working on developing such formulations using bioplastics and biobased materials by combining plastics with perennial grasses, food wastes, industrial co-products, and pyrolyzed biomass and wastes in engineering next generation of injection moulded biocomposites. Demand for all new carbon-based composites (comprising both the filler, fiber and resin from renewable resources) is growing, with immense opportunities in 3D printing with innovative design for light-weight eco-friendly complex shaped auto-parts. This presentation will highlight the growth of natural fiber composites towards more advanced sustainable materials, by substituting short glass fibre and mineral-filled injection composite materials for light-weight auto-parts.

Developing Structural Natural Fiber Parts Using Spray Transfer Molding (STM) Process

Elias Shakour, BASF Corp

This paper will discuss using the new process technology Spray Transfer Molding (STM), where the fabric is impregnated locally outside the mold using a high-pressure spray process then molded in a compression press. A blank of dry fiber is held by a programmed robot that has an optimized and controlled spray pattern. Once sprayed using a high-pressure nozzle head atomizing the spray polyurethane, the robot will lay down the impregnated blank into the tool to be fully molded and cured. The cycle time from part to part for such a process will be completed in 90 seconds. In this study, a state-of-the-art bamboo random fabric mat will be laid on top and bottom of honeycomb to make a honeycomb sandwich parts. The study will show that bamboo fiber can be a good replacement to glass fiber due to its high mechanical performance that can be equal if not more than the glass fiber.

Post-Consumer Recycled Based High-Heat PA6,6 Development for Turbocharged Air Intake Ducting

James Kempf, Wellman Advanced Materials

Usage of carpet-based PA6,6 materials in an elevated thermal environment plays to the strengths of these materials due to the inherent thermal behavior. In this session, we will discuss the status of development of this resin and the natural advantages of this resin in applications requiring performance retention after long-term heat exposure.

SUSTAINABLE COMPOSITES - 2/5

3RD PLACE BEST PAPER

Latest Breakthroughs with Hybrid Reinforced Composites in Lightweight Applications

Author:Dinesha Ganesarajan,
University of Waterloo

Presented by: Leonardo Simon,
University of Waterloo

Natural fibers are abundant and provide many advantages such as: weight reduction, process-friendliness, biodegradability and good acoustic insulation properties. The limitations of natural fibers as reinforcement for thermoplastics are their low mechanical properties, limited thermal stability and shrinkage in comparison to traditional inorganic reinforced thermoplastics. In this study, the objective was to develop hybrid composites combining poly α-1,3-glucan (DuPont's Nuvolve™) along with long glass fiber in a polypropylene matrix to optimize the overall composite properties for automotive applications (body interior and underhood). The samples were prepared using a two-step process: twin-screw extrusion followed by injection molding. The results showed mechanical properties decreased with increasing polysaccharide content, however an optimal loading combing Nuvolve™ and glass fiber yielded improved mechanical properties that exceeded Ford Motor Company's incumbent material specification for body interior and underhood applications. Thermal & morphological analyses were also conducted to understand filler-matrix interactions and thermal stability of the composites. Overall the hybrid reinforced composites can lead to weight and cost savings with the promise to advance environmental stewardship within the automotive realm.

ABSTRACTS 2019

Characterization of Hybrid Composite Based on Kenaf and Glass Fibers for Underbody Shield Applications

Sandeep Tamrakar, Ford Motor Co.

Water absorption behavior of compression molded composites used for automotive underbody shield application was investigated at ambient (23°C) and elevated (70°C) temperatures. Three types of composite specimens: all-glass (25% by wt.), all-kenaf (25% by wt.) and hybrid (12.5% glass and 12.5% kenaf by wt.) with PET matrix and ACRODUR® binding agent were considered. Composite specimens saturated at ambient temperature were subjected to freeze thaw cycling ranging from 23°C to -29°C, extended freeze at -29°C and re-drying. To assess the effect of water absorption on mechanical properties, standard three-point bending tests were carried out. Degradation in mechanical properties was found to be a strong function of water absorption. At dry condition, both flexural modulus and strength for hybrid and all-kenaf composite were much higher compared to all-glass composite. After saturation, despite being significantly affected by water absorption, the mechanical properties of all-kenaf and hybrid composite were comparable to the saturated all-glass composites. As expected, the mechanical properties of composites saturated at 70°C were severely affected. However, freeze-thaw cycling and extended freeze did not have any significant impact on the mechanical properties of the saturated composites. Interestingly, the flexural strength for all composites increased after the saturated specimens were re-dried. This phenomenon was attributed to the added crosslinking in the ACRODUR® matrix.

ENABLING TECHNOLOGIES - 4/4

Development of Modified Polypropylene (PP) Products with Low-Odor for Automotive Interior Parts

Esra Erbas Kiziltas, Wellman Advanced Materials

Development of modified polypropylene (PP)products with low odor for automotive interior parts has been successfully achieved by PRET and Wellman Advanced Materials. In this submission, we will present methods of testing and detection of materials with high emissions/strong odors, methods and key factors for development and production of low-odor PP resins and multiple successful examples of products which have been produced in production with low odor including door panels, consoles, instrument panels.

Does a Fiber Reinforced Thermoplastic Door Structure Meet the Energy Absorption Requirements for a Side Impact Crash Test?

Dr. Srikanth Pilla, Clemson University

Lightweighting of closure systems is increasingly gaining steam as they account for 35-50% of a cars structural mass. However, the adoption of composites has met challenges given their engineering complexity and stringent performance requirements like durability, NVH, and crash. This project tries to address this by designing and developing a door which is 42.5% lighter than the baseline while meeting all functional requirements at a cost increment of ~$5 per pound weight saved. Fiber reinforced thermoplastics offer the ideal tradeoff between specific properties, short cycle times and cost. However, a major barrier for their adoption is understanding their failure behavior in nonlinear crash environments. Our presentation delves into the process of designing a thermoplastic composite door and developing robust simulation methods to validate and optimize its crash response. This includes details on the development of robust material cards and their experimental validation at coupon and component level. These robust simulation methods form the cornerstone to rapidly iterate and develop a composite door frame that meets and surpass the crash performance of the baseline metal door.

Mold-Shutter and Double-Deck Frame Systems Improve the State-of-the-Art HP-RTM, LCM, and Prepreg Compression Molding Technologies

M. Andolfatto, Cannon USA

A plugin pressure-holding device (patent-pending) was designed to compensate the chemical resin shrinkage naturally arising in traditional HP-RTM processes, by controlling the post-injection pressure in order to improve the mechanical properties of the parts, and largely improve surface quality. In order to improve the HP-RTM productivity, an embedded mold-shutter (patent-pending) has been designed to seal the mold cavity immediately after the injection phase, allowing a safe removal of the mixing head without pressure loss; one dosing system and mixing head can thus be used to serve multiple molds and presses. This technique can be combined with the concept of transfer line, a turn-key solution capable of handling multiple molds at the same time and allowing for cycle time optimization and increased productivity. In order to produce parts with LCM (Liquid Compression Molding) either with a complex geometry or multi-material stacks (e.g. including rigid cores and inserts) a double-deck frame (patent-pending) has been developed, in order to hold the material in-between two layers of plastic film, sustained by direct vacuum action, during the handling and forming phases of the production process.

SUSTAINABLE COMPOSITES - 3/5

Methodology to Use PCR (Post-consumer Recycled) Polyamide Material as an Alternative Solution to Prime Polyamide in Automotive Applications

Taehwan Kim, Wellman Advanced Materials

Despite the great potential to reduce costs and increase sustainable content in automotive applications, insufficient knowledge and experience with PCR material has caused its implementation in automotive parts to be challenging at times. During this session, we will convey the value creation potential, strengths and weaknesses, as well as best practices to maximize performance using recycled materials.

Quality Controls of Post-consumer Recycled Carpet-Based Resins for the Automotive Industry

Donald Wingard, Wellman Advanced Materials

Wellman Advanced Material's Engineering Resins Division has provided post-consumer recycled (PCR) based resins to the Automotive Industry since 1996. High quality standards of the PCR resins are essential to meet material, part, and customer requirements. In this submission we will discuss the quality systems that have been established from incoming post-consumer whole carpet to finished compounded product. Wellman Engineering Resins is fully integrated from carpet collection to finished product. A total of 24 quality checks has been established for this product realization process. Wellman's quality labs are A2LA accredited with a range of capabilities that extend from physical property testing to composition analysis.

PEARL ROOM

BUSINESS TRENDS AND TECHNOLOGY SOLUTIONS - 1/2

Advances in Motor Encapsulation

Stephen Greydanus, Hexion

Presently, vehicles with internal combustion engines are by far the most popular choice of powertrain. However, concern for the environment has led to policy targets on carbon emissions both globally and at the EU level, therefore alternative powertrains like hybrid, electrical or fuel cell will play an increasing role in the transport policy mix. Electrical motors where the magnetic field is electrically induced are very efficient at high rotational speeds and can provide exceptional acceleration. In such induction motors the rotor coil wires are fixed in place to avoid unbalance leading to motor destruction. An encapsulation with high Tg epoxy systems provides sufficient crack resistance at -40°C and good mechanical strength at the operating temperatures reaching 150 to 200°C. This is supported with predictive modelling to calculate the crack resistance and strain at break. These findings finally help to optimize the manufacturing process and define the minimum fracture toughness of an encapsulation system in order to secure sufficient safety when operating electrical motors. The paper will illustrate the described advances in motor encapsulation.

Development of Ultra-Light Hybrid Glass Fiber and Polymeric Fiber Reinforced Polypropylene Composites

Hongyu Chen, Hanwha Azdel

It is a trend in the automotive industry to pursue materials with improved strength-to-weight ratio. Light weight reinforced thermoplastic (LWRT) composites represent one type of these desired materials. This study reports development of a new LWRT material with a significantly improved strength-to-weight ratio over standard LWRT materials. A novel ultra-light reinforced thermoplastic composite, which features the mixed usage of glass fibers and bi-component polymeric fibers, is reported. Polymeric fibers provide a low density reinforcement, while glass fiber has better strength and stiffness. Through hybridization, it is possible to design the material to suit various applications more closely. The hybrid effects of glass and polymeric fibers on the flexural and physical properties have been investigated. It has been found that the partial substitution of glass fiber with bi-component polymeric fiber helps further reduce weight without sacrificing the mechanical strength of the material.

Sandwich Construction Provides New Design Solutions for Body Structure & Trim

Russell Elkin, Baltek Inc.

While sandwich construction is a well-known solution to the problem of creating high stiffness, low weight parts, it is not common to the automotive market. This presentation will endeavor to review how specific sandwich core materials, especially suited to support high volume, short cycle automotive production, can enable the designer to meet functional requirements in the areas of body structure and trim.

BUSINESS TRENDS AND TECHNOLOGY SOLUTIONS - 2/2

Structural Validation of Material Model and CAE Method Accounting for Sheet Molding Compound (SMC) Process

Pierre Savoyat, e-Xstream engineering

Though Sheet Molded Compound (SMC) material has long been considered quasi-isotropic with relative success, it has become apparent in the automotive industry that due to the complex manufacturing process, optimal structural design is not possible without considering the real anisotropic nature of the material. With growing demand from the market, now is the time to leverage advanced SMC modeling capabilities targeting crash performance. The SMC material label refers more to a process than to a grade and SMC materials share significant similarities with beam molded compound (BMC) materials. This process consists of placing one or more charges, which are cut out of raw mat rowing and piled into several layers, into a mold cavity before closing the mold and forcing the material to flow in accordance with the pattern coverage. Most SMC grades are composed of bundles or uni-direction (UD) scraps. From such a starting point and manufacturing process, SMC grades can range from dispersed long fiber reinforced plastics (LFRP) to discontinuous fiber chips (DFC). In this presentation we will showcase how to simulate with greater confidence the SMC part response and achieve more accurate stiffness, peak load and load drop displacement.

ABSTRACTS 2019

Plant Based Composite Materials for Automotive: They Exist and Are Ready for Prime Time

Mark Remmert, Green Dot Bioplastics Inc.

Plant based biopolymers and biocomposites offer two unique selling points, or value propositions, highly desirable to today's consumers and end users. The materials are more sustainable than traditional polymeric materials being derived in-part, or wholly, from plant based, renewable raw materials. These biocomposites are non-toxic in process and use. They use little, if any, water in manufacturing or conversion and have no VOC or water discharge in manufacturing or use. Secondly, biocomposites offer the possibility of light weighting versus traditional glass filled composites while offering similar or superior, strength-to-weight comparisons.

BONDING, JOINING AND FINISHING - 1/1

Composite Sandwich Repair Using Through-Thickness Reinforcement with Robotic Hand Micro-Drilling

Alex Kravchenko, Old Dominion University

In this study we investigate the crack arrest behavior and repair of composite sandwich beams with embedded delamination and disbond cracks. To suppress crack propagation, through-thickness reinforcement (TTR) is used by installing them into the face-sheet laminate using micro-drilling operation performed by robotic hand setup. Composite sandwich manufacturing methodologies are presented with the focus on the role of face-sheet/core interface on the effectiveness of TTR technique. Specifically, TTR is shown to suppress propagation of delamination or disbond crack, placed on the compressive side at the mid-span location of 4-point bending composite sandwich. Furthermore, the effectiveness of TTR repair under combined crack propagation and face-sheet failure of the sandwich beams with and without presence of adhesive layer is considered, which provides a case of strong and weak face-sheet/core interface respectively. 3D FEA was used to evaluate the reduction in the crack driving force due to the presence of TTR. Stiffness and strength of repaired composite sandwich are recovered using the proposed technique, which indicates high effectiveness of TTR in the suppressing crack propagation and restoring structural load carrying capacity in composites. The present technique offers novel approach for automation of repair for various crack configurations in high-performance structural composites.

Primerless Structural Adhesives for Bonding Low Surface Energy Composites

Michael Barker, Ashland, LLC

Regulations mandating improved automotive fuel efficiency and reduced carbon emissions as well as the market trend to purchase larger crossover vehicles continues to drive the need for lighter weight vehicle technology. The resultant use of thermoplastic olefin-based composites for exterior body panels has created need for adhesives capable of bonding their low energy surfaces. Surface preparation such as flame treatment and primer application can assist the bonding process but also add cost to the assembly. The adhesive must also accommodate relative movement in the joint due to in-service temperature fluctuations. Reducing the modulus and increasing the elongation of the adhesive can offset these differential thermal movements. This study will review the efficiencies of the available surface treatment techniques to enable adhesion and will use finite element analysis (FEA) to establish directional goals for the adhesives' constitutive properties to create a durable adhesive bond. Finally, a new hybrid primerless adhesive will be introduced capable of creating reproducible, strong, durable bonds with minimum surface preparation.

Plasma Surface Engineering of Fiber Reinforced Composites for the Removal of Contaminants and Improvement of Adhesive Joint Strength

Daphne Pappas, Plasmatreat USA, Inc.

Over the past few decades, the automotive and aerospace industries have shown increased interest in carbon fiber reinforced plastic composite (CFRP) materials due to their light weight and low production cost. However, these composite materials exhibit poor performance in structural applications due to the weak interface when bonded to other dissimilar materials, such as adhesives, metals and polymers. Treatment under atmospheric pressure plasmas (APPs) has emerged as an alternative solution to engineer composite surfaces without affecting the bulk properties of the materials. APPs contain gaseous species that can react and remove organic surface contaminants very rapidly. Furthermore, they can be instrumental in the chemical functionalization and activation of the surface through the grafting of oxygen-based polar groups. Literature references report the increase of surface energy, improved fracture toughness and increase of adhesive strength due to the APP treatment. In this talk, we will present the details of the application of an Openair® air plasma process on fiber reinforced composites and results from the improved adhesive strength.

REINFORCEMENT TECHNOLOGIES - 1/1

Hybrid Composites for Automotive Applications – Development and Manufacture of a System-Integrated Lightweight Floor Structure in Multi-Material Design

Tobias Link, Fraunhofer-Institute for Chemical Technology

The publicly funded research project SMiLE "System-integrated multi-material lightweight design for e-mobility" is developing a detailed understanding of efficient lightweight construction using intelligent FRP-metal multi-material design. A central

research focus is the use of composites for complex, three-dimensional structural components in an automotive series production. The project addresses fiber-reinforced plastic (FRP) components with a thermoplastic and a thermoset matrix. For the processing of semi-finished continuous-fiber-reinforced thermoplastics in combination with long-fiber-reinforced thermoplastics (LFT), a novel compression molding process was developed: the so-called "local advanced tailored LFT-D process". This process enables manufacturing of local ribs on a laminar insert, thus reducing the wall thickness while enabling a higher stiffness. For the production of CFRP components based on thermoset matrix systems, the innovative pressure-controlled resin transfer molding (PC-RTM), developed within the project SMiLE, is used. This technology offers a high-volume production process for high-performance and cost-effective CFRP parts with thermosetting matrices and integrated foam cores for structural applications. The key to success is an innovative process control as well as the use of optimized materials.

Rheological Behavior of Basalt and Hemp Fiber Reinforced Thermoplastic Composites

Vikram Yadama, Washington State University

Rheological behavior is studied to know the flow of material under the circumstances in which they respond with the plastic flow instead of deforming elastically due to the applied force. From this we can analyze the rigidity and viscosity of the materials wherein rigidity decreases with the increase in temperature. Resin flow and permeability behavior should be understood to produce quality products with consistent performance. This study sought to develop the methodology to produce basalt fiber reinforced in thermoplastic resin and methodology to produce extruded and injection molded composite specimens. The presentation will focus on the influence of basalt and hemp fibers with MAPP coupling agent and resin factors on the flow and performance of molded composites. Mixture model design was implemented to understand the effect of various proportions of basalt fiber, hemp, MAPP, and PP resin. Rheological behavior of these proportions was investigated. The ideal proportions were extruded and injection molded to evaluate the performance of the composite material. The presentation will discuss the influence of MAPP and temperature on composite processability and the mechanical performance of the composite material.

FRIDAY SEPT 6

KEYNOTE 3 -

Composites on the New Chevrolet Corvette

Ed Moss, Engineering Group Manager, Corvette Body Structures, General Motors Co.

Ed Moss, General Motors Engineering Group Manager for Corvette Body Structure, will highlight the use of composites on the all-new 2020 Chevrolet Corvette Stingray. Precise and powerful, the Corvette Stingray has been completely redesigned from the ground up to deliver a thrill on every drive. The body structure boasts many innovative elements to become the stiffest Corvette ever, utilizing lightweight composites to integrate functional elements into its form.

- The 2020 Stingray maintains Corvette's signature aluminum frame, innovative SMC and carbon fiber underbody components and the SPE award-winning lightweight exterior SMC body panels.
- Corvette continues to lead the automotive industry in the use of lightweight composites, and the 2020 Stingray introduces the automotive industry's first curved, multi-hollow, pultruded carbon fiber bumper beam.
- The Corvette offers class-leading storage for a mid-engine vehicle. It features front and rear storage units that are constructed of an industry-first "Float SMC", which boasts a specific gravity less than 1.0.
- The jewel to the car's setting, the all-new LT2 V-8 engine, is visible through a large window mounted to the low-density SMC rear hatch.

ONYX ROOM

VIRTUAL PROTOTYPING, TESTING AND MODELING - 1/2

Fatigue Characteristics of a Random Carbon Fiber SMC-R Composite

Monish Urapakam Ramakrishnan,
University of Michigan, Dearborn

Randomly oriented short fiber reinforced sheet molding compound composites (SMC-R) are among the most commonly used composites for automotive and many non-aerospace structural applications. There is also a growing interest in using carbon fiber SMC-R composites in structural components in both the automotive and aerospace industries. The current study

considers fatigue characteristics of a randomly oriented carbon fiber SMC-R under both uniaxial and biaxial stress conditions. A modified Arcan specimen was used to conduct the biaxial stress tests. Since the fatigue life data exhibited significant variation, a statistical analysis was conducted to analyze and predict the variations in the fatigue life of the material.

CAE Chain-Based Optimization Strategies for Fiber Reinforced Composites Parts as a Key Element for Future Lightweight Design

Benedikt Fengler, SIMUTENCE

Optimization tools generally require problem-specific strategies to find the best solution. As part of the product development process, a commonly used optimization objective is to achieve the maximum stiffness for a component with a given material and design space. For lightweight applications, the combination of multiple material types offers additional optimization potentials. In this work, a combination of discontinuous and continuous fiber reinforced polymers (FRP) is aspired, therefor an optimization workflow is presented. With respect to the two material classes used, continuous and discontinuous FRP, the optimization procedure will be split up in two steps. First the continuous fiber reinforced part is optimized to derivate a ply layup which meets the engineering requirements. Afterwards, a topology optimization is performed to identify the derivate the ideal shape of the discontinuous fiber reinforced material. Since manufacturing effects significantly influence the performance of fiber reinforced composites, their consideration is crucial for a reliable part design. Therefore, a virtual process chain is used in the work presented, in which information is mapped in-between the simulation steps.

VIRTUAL PROTOTYPING, TESTING AND MODELING - 2/2

Modeling Morphology and Physical Properties of Nanocomposites Using Molecular Simulation

Jeffrey Sanders, Schrodinger, Inc.

The matrix surrounding carbon fibers is important to the behavior of composites. As the use of composites has grown, so has the need for better tools to predict and understand how the chemistry of the matrix impacts performance. This work highlights tools in computational chemistry developed for composite matrices and how it has become a practical tool for composite materials engineers and scientists to have in their toolbox. Several relevant examples in the automotive industry, including thermoplastics and nanoparticle additives, will be explored. Additionally, we will explore how molecular simulation can be applied to study composite material interfaces.

Composites Forming: Advanced Modeling & Simulation

Tonya Cole, Dassault Systémes
Alireza Forghani and Paulo Silva, Convergent

Many industries, including automotive, aerospace and energy, are facing multiple challenges related to the design and manufacturing of composite components. As parts become more complex, and materials continue to advance, new automated manufacturing methods have been developed. While the automation of these new processes helps reduce variation and overall production cycle time, they can be difficult to accurately simulate. This is why Dassault Systémes and Convergent Manufacturing Technologies have teamed up to develop an integrated workflow that allows designers and manufacturing engineers to simulate the composite forming process with disruptive, yet scalable software technologies. This presentation will highlight some of the current industry challenges related to manufacturing complex composite parts, showcase advanced modeling, and simulation tools dedicated to the forming manufacturing process, and provide a deep dive into the integrated workflow using Convergent's software technologies and the CATIA Composites Forming solution.

OPAL/GARNET ROOM

OPPORTUNITIES & CHALLENGES WITH CARBON COMPOSITES - 3/4

FEATURED TALK

Suitability of Carbon Fiber Composites in a High-Volume Production Process for Vehicle Front Subframes

John Ingram, Magna International, Inc.

This collaborative research project investigates potential mass savings and highlights the technical opportunities and challenges of utilizing carbon fiber (CF) composites in a front subframe for the Ford Fusion. The design predominantly used CF sheet molding compound in two large compression molded thermoset parts, a clamshell shaped upper with over-molded steel reinforcements and a lower close-out panel. Both parts contained co-molded, non-crimped fabric patches for local reinforcement. The CF composite subframe weighs 18.8 kg and reduces components from 45 to 8. This represents a 28% mass savings from the production stamped steel subframe and an 82% part reduction.

Projected tooling expenditures are approximately US $4 million dollars, a substantial savings over tooling for a stamped and metal inert gas (MIG) welded steel subframe. The estimated variable cost is approximately three to four times that of a traditional stamped steel subframe. Use of carbon fiber composites in the automotive industry will become more prevalent as the cost of carbon fiber roving, and costs and complexity of composite manufacturing operations are reduced.

Carbon Fiber Subframe Development – Corrosion Mitigation Strategies and Test Results

David Wagner, Ford Motor Co.

A research carbon fiber reinforced polymer, CFRP, composite front subframe was designed and manufactured for the Ford Fusion to investigate the opportunities to reduce weight and improve fuel economy, as well as the challenges associated with composites. Cyclic corrosion testing was conducted to check for the occurrence of galvanic corrosion on metal parts and bolts joined to the CFRP subframe. Some interfaces were tested with potential mitigation actions in place, such as e-coated steel for control arm brackets, stainless steel for compression limiters and rivets, glass veil design with machined carbon fiber faces and Nylon 11 over-coating on washer and bolt shanks. A vehicle and four components were tested to evaluate the subframe assembly corrosion performance. Posttest parts were analyzed for part damage and material loss. The CFRP subframe achieves a 7.3 kg (28%) mass reduction over a stamped steel subframe and an 82% part reduction by replacing the 45 steel parts with two molded parts and six inserts.

OPPORTUNITIES & CHALLENGES WITH CARBON COMPOSITES - 4/4

2ND PLACE BEST PAPER

Carbon Fiber Subframe Development – Fatigue and Strength CAE and Test Results

Xiaoming Chen, Ford Motor Co.

A research carbon fiber composite front subframe was designed and manufactured for the Ford Fusion to investigate the opportunities and challenges associated with this lightweight material to potentially improve fuel economy. The design process was CAE driven verified with component tests and proving ground vehicle tests. CAE output demonstrated that the carbon fiber composite subframe met performance targets for both high cycle fatigue and critical event strength durability. Component tests were conducted to verify the subframe's fatigue performance under high cycle loads and strength under quasi static loads. Proving ground vehicle durability test and strength related special event tests were also conducted. The CAE predictions for the component and vehicle tests had various degrees of correlation with the physical test results. Improvements in CAE procedures and material characterization will likely be needed to generate robust CAE predictions of carbon fiber composite structural performance.

Carbon Fiber Subframe Design and CAE

Nikhil Bolar, Magna International, Inc.

A carbon fiber composite front subframe was designed and manufactured for the Ford Fusion to reduce weight and improve fuel economy. The CAE driven design process of this compression molded thermoset subframe was verified by finite element analyses to meet the structural performance targets. The composite material utilizes chopped carbon fiber compounded with a modified vinyl ester resin system, EpicBlend™ CFS-Z SMC. (EpicBlend™ is a trademark of Magna International Inc.) Co-molded with the chopped fiber is a second carbon fiber composite material, a pre-preg that utilizes continuous 0o/90o non crimped fabric (NCF). The two composite materials were approximately 50% chopped fiber and 56% continuous fiber by weight respectively. This combination of materials achieves a 7.2 kg (28%) mass reduction over a stamped steel subframe. Additional innovations include SMC over molded stainless-steel inserts at the body and steering mount locations and CFS-Z energy absorbing front horns. A dramatic 82% part reduction is achieved by replacing the 45 steel parts with two molded parts comprising of an upper section and a lower close-out, joined by adhesive bonding plus structural rivets.

EMERALD/ AMETHYST ROOM

SUSTAINABLE COMPOSITES - 4/5

Investigation of Variations in Closed Cell Foamed Polymer Composite Structures

Daniel Pulipati, Baylor University

The purpose of this research is to study the closed cell foam properties as seen in a cross section of composite structures fabricated from recycled polymer post-consumer/post-industrial waste composed of HDPE (High Density Poly Ethylene) and PP/FG (Poly Propylene/Fiber Glass). The ties fabricated using blowing agent enabled extrusion techniques have a solid shell region on the outer surface and a closed cell inner foamed core. A technical challenge in predicting the final part performance is a limited understanding of the micro-structural variations contributing to the spatially varying material properties within the composite structure. Imaging techniques were used to quantify the effect of various parameters such as cell size distribution and density of the closed cell samples on the material properties of the composite structure.

Food Industry Waste-Derived Biocarbon and Biobased Engineering Thermoplastic for Sustainable Composite Applications

Maisyn Picard, University of Guelph, Bioproducts Discovery and Development Centre

Globally, 1.3 billion tonnes of food waste is generated each year, some of which is food industry waste in need of valorization. Value-added products from pyrolyzed wastes have been used as sustainable natural fillers in composites applications. This presentation features the novel use of peanut hull biocarbon with biobased engineering thermoplastic. The biocarbon was generated at 500ºC and 900ºC under nitrogen atmosphere. A complete thermal and morphological analysis was completed to determine the biocarbon possessed exceptional thermal stability as compared to traditional natural fillers with maximal degradation

temperature in excess of 300ºC. A distinctive surface morphology of the biocarbon and improved thermal stability suggested the use of peanut hull biocarbon with poly(trimetheylene terephthalate) for composite applications. Thermal and mechanical properties of peanut hull biocarbon were analyzed and it was found that 900ºC biocarbon experienced better overall performances than 500 ºC biocarbon. However, both biocomposites experienced more than 115% improvement in moduli over the neat polymer. Successful fabrication of biocomposites suggested their use in automotive applications.

SUSTAINABLE COMPOSITES - 5/5

Development of Sustainable Hybrid Composites Using Recycled Polypropylene and Engineered Polysaccharide

Sea Ho Jeon, Wellman Advanced Materials

Sustainable material development has recently become the focal point of study in both academia and industrial settings. The industrial applications range from furniture to automotive to construction and beyond having the potential to influence every aspect of a consumer's daily routine. This eco-friendly approach to find new material draws the attention of not only environmentalists, but also businessmen and researchers/engineers. This study focuses on the use of recycled polypropylene as post-consumer resin (PCR) for hybrid composites. Micron-sized polysaccharides were introduced into the resin along with short glass fiber to improve the mechanical and physical properties. The goal of this research was to identify a cost-effective, lightweight, and sustainable replacement for 30% glass filled polypropylene material that meets or exceeds current automotive specifications.

Improved Utilization of Downstream Corn Oil from Bioethanol Industry: Super Performed Sustainable Flame Retardant for Engineering Plastic-Based Biocomposites in Automotive Applications

Boon Peng Chang, University of Guelph

Many plastic components in automotive applications have serious issues with easy flammability. Flame retardants (FR) are vital additives to combat this. Halogen-based FR have been used heavily in the past for this purpose. However, these materials produce gases upon burning that may cause human health and environmental issues. Halogen-free FR are gaining in popularity to replace these traditional FR. In this work, phosphorylated downstream corn oils from bioethanol industry were synthesized through ring opening reactions for use as FR in engineering plastics. The flame retardancy of poly(butylene terephthalate) (PBT) and poly(trimethylene terephthalate) (PTT)-based composites were improved from non-rating to V-2 fire classification in UL-94 flame tests. The fire mechanisms were investigated and discussed in detail. The preliminary test of this FR showed promising results for use in engineering plastic composites as a replacement for traditional FR. The implementation of this biobased FR into composites designed for automotive use has potential to create safer, more environmentally friendly automotive components.

PEARL ROOM

ADDITIVE MANUFACTURING AND 3D-PRINTING - 4/5

Multi-scale Modeling of Additive Manufacturing: From Process Simulation to Design Validation

Dustin Souza, e-Xstream engineering

Additive Manufacturing of polymers brings valuable opportunities to the industry, such as drastically decreasing the time-to-market of new products or enabling lightweight, multi-material and multi-functional designs. The reliability of the mechanical properties of the final part still has some uncertainty and is not fully supported by standard engineering tools. Dimensional accuracy is not always met and cannot be predicted prior to printing. A holistic simulation approach for additive manufacturing of plastics and composites is proposed, covering material engineering, process simulation and structural engineering of both SLS and FDM. The multiscale material modeling techniques – which are essential to handle the several scales involved in Additive Manufacturing - will be presented and discussed. The very strong influence of the manufacturing on the material and global component behavior is illustrated in industrial applications and the validity of this integrative approach is demonstrated in several applications, including warpage predictions, the computation of the effective mechanical response of lattices and as-printed part performance simulations (stiffness, strength, …) as a function of the material and the printing process parameters such as toolpath.

Effects of Flow-fiber Coupling on Melt Flow Rheology in Large Area Polymer Composite Additive Manufacturing

Zhaogui Wang, Baylor University

Discontinuous fiber reinforced composites continue to see increasing application in large area material deposition additive manufacturing. Rheological behavior of molten polymer feedstock is critical in the manufacturing process where the shear thinning response of a fiber-filled polymer is significantly different from its virgin polymer alternative. Additionally, extrudate swell directly affects the resolution of a printed part in polymer extrusion-based additive manufacturing. The presence of fibers and their associated alignment greatly affect the properties of the polymer composite melt flow. This study quantifies the effect of the fiber orientation on rheological behaviors of the melt flow through a finite element based fully coupled scheme between the flow kinematics and fiber orientation kinetics. Our computed results indicate that the magnitude of the flow velocity field along the direction of the flow is increased due to the presence of certain fiber alignment. And the die swell ratio of a fiber filled polymer composite is much less than that of a neat polymer material. Accordingly, fiber-orientation-induced variations on flow rheology requires that the material feeding rate and printing path need to be adjusted when using filled polymers over their virgin alternatives, especially for large area additive manufacturing applications.

ADDITIVE MANUFACTURING AND 3D-PRINTING - 5/5

Topology Optimization for Lightweighting Anisotropic Additively Manufactured Parts Under Thermomechanical Loading

Jackson Ramsey, Baylor University

Topology optimization has emerged as an effective design approach that can optimize the performance of lightweight automotive parts having complex geometries suitable for additive manufacturing. However, most additively manufactured structures have anisotropic material properties, especially those composed of fiber-filled polymers. In addition, residual thermal stresses arise from nonisothermal cooling processes during manufacturing which has yet to be incorporated into topology optimization. This paper presents a new topology optimization-based approach that incorporates both material anisotropy and weakly coupled thermomechanical loading into the design computations. In our approach, design derivatives are evaluated using the adjoint variable method specifically for the weakly coupled thermomechanical system. An optimality criterion-based update scheme minimizes the compliance or strain energy within the design space over material density and anisotropic orientation. The coupled thermomechanical analysis and material direction optimization reflects the anisotropic Young's modulus and thermal stresses present in large-scale polymer deposition. Resultant structures show how thermal loading influences the optimal topology.

Sustainable Biocomposites from Biobased Engineering Thermoplastic and Biocarbon Through Additive Manufacturing

Elizabeth Diederichs, University of Guelph

Thermoplastics have strong potential in additive manufacturing due to their superior mechanical and thermal properties. Poly(trimethylene terephthalate) (PTT) is a semi-crystalline engineering thermoplastic with a strong potential for 3D printing. Fused deposition modelling (FDM), a method of 3D printing was focused on in this work due to its strength in rapid prototyping and its ability to generate complex geometries. Due to its semi-crystalline nature, PTT has challenges with warpage and delamination during FDM, therefore it is difficult to print finished parts. For successful printing, a chain extender and impact modifier were blended with the PTT. Important modifications made to the PTT included increased filament diameter and consistency, and decreased MFI and crystallinity. The additives allowed for a warpage-free, printable material with the added benefit of increased toughness. Sustainable biocarbon from miscanthus fiber was incorporated into the optimal blend of PTT bioplastic (~37% biobased content), chain extender, and impact modifier to create biocomposites, increasing the biocontent further to more than 50% in the resulting biocomposites. Analysis of these composites determined their interfacial adhesion, surface/layer morphologies, and mechanical and viscoelastic properties. There is exceptional potential of these blends and composites for use as new feedstocks well suited to the additive manufacturing field.

SCHOLARSHIP

SPE® ANNOUNCES WINNERS OF THE ACCE & DR. JACKIE REHKOPF SCHOLARSHIPS FOR THE 2019-2020 ACADEMIC YEAR

The three winners of the SPE ACCE scholarships ($2,000 USD each) are **Martin Eichers,** a student at North Dakota State University, **Priya Venkatraman,** a PhD candidate at Macromolecular Science and Engineering, Virginia Tech, and **Bradley Sutliff,** also a PhD candidate at Macromolecular Science and Engineering, Virginia Tech.

The Dr. Jackie Rehkopf Scholarship is sponsored by the SPE Automotive Division, the SPE Composites Division and generous donations from friends and family. The two winners of the Rehkopf scholarship ($5,000 USD split between the two) is **Mariana Desireé Reale Batista,** a PhD candidate in Materials Science and Engineering at Michigan State University, in the Composite Materials and Structures Center, and **Akshata Kulkarni,** a PhD candidate in Polymer Engineering, University of Akron. Both scholarships are administered as part of the SPE Foundation®.

Martin Eichers is a senior at North Dakota State University (NDSU) majoring in Mechanical Engineering with minors in Chemistry and Coatings and Polymeric Materials. Martin is the project lead for the Formula SAE Electric team and president of the 3D Printing Club at NDSU. As a research assistant in the Mechanical Engineering Department, Martin works to develop low-cost biocomposite PLA 3D printing filament by designing various material formulations and manipulating manufacturing conditions to produce the strongest filament. After extruding a new filament, he determines its properties through mechanical testing. He became interested in polymeric materials after learning more about 3D printing. His career goals include to providing 3D printing and materials expertise to assist in the development of new technologies for the aerospace, automotive, and biomedical industries.

Priya Venkatraman is currently a PhD candidate pursuing a degree in Macromolecular Science and Engineering (MACR), in the Macromolecules Innovation Institute (MII) at Virginia Tech. Her research is comprised of the design, processing, and characterization of nanocellulose composites with applications in producing environmentally sustainable, lightweight material alternatives for use in various industries including automotive and aerospace. Through her active involvement in the nanocellulose community, Priya was elected chair of the Technical Association of Pulp and Paper Industry (TAPPI) Nano Student Committee in 2018, where she previously served as the Student Engagement Subcommittee Chair. Her involvement with SPE has been an integral part of her graduate career as well, facilitating her knowledge of the polymer engineering community. Priya is currently organizing and serving as co-chair of the National Graduate Research Polymer Conference, which is set to be hosted at Virginia Tech in 2020. She intends to pursue a career in research and development to improve industrial-scale polymer engineering processes and develop materials with unique, enhanced properties, while being more mindful of the environmental impact. Priya will be defending her dissertation in the upcoming academic year (2019-2020).

AWARDS

Bradley Sutliff is a third-year PhD student at Virginia Tech, studying Macromolecular Science and Engineering. Under the advisement of Dr. Michael J. Bortner, Brad studies the rheology of cellulose nanomaterials similar conditions to current industrial processes. Prior to this he earned a Master's degree in biomedical engineering at Syracuse University. At SU, he manipulated bacteria to produce polyhydroxyalkanoates, a category of biopolymers that show promise for medical devices and environmental degradation. As a staunch supporter of developing bioplastics for both medical and general usage, he understands such materials will not succeed if they cannot meet current industry needs. This has focused Brad's career on not only studying bio-based materials, but also interacting with the plastics professionals of the world to identify their requirements and questions. To this end, SPE has been a tremendous help, allowing Brad to meet many professionals at his first ANTEC® in 2019. He is currently in his second year as the president of the SPE student chapter at Virginia Tech, and has recently joined SPE's Next Generation Advisory Board. This year, Brad will be focusing on growing VT's student chapter, and on planning the National Graduate Research Polymer Conference (NGRPC) for July 2020 at Virginia Tech.

Mariana Desireé Reale Batista is currently completing her PhD studies in Materials Science and Engineering at Michigan State University, in the Composite Materials and Structures Center under Professor Lawrence Drzal's supervision. Her research is focused on developing lighter, safer, more sustainable and cost-effective materials for components used in automotive and aerospace industries. She is investigating polymer composites, specifically the modification of the fiber-matrix interphase with nanoparticles, to simultaneously strengthen and toughen the composites and impart multifunctionality to them. She has been optimizing the adhesion of carbon fiber reinforced composites through the incorporation of Cellulose Nanocrystals and optimizing the mechanical properties of bamboo fiber reinforced composites by incorporating Graphene Oxide at the composite interphase. She interned at the Ford Motor Company (Research and Innovation Center), where she developed lightweight hybrid cellulose-inorganic reinforcement composites for automotive applications. More recently she interned at NASA (AMES Research Center) developing flexible UV sensors. Batista graduated summa cum laude with a B.S. degree in Mechatronics Engineering and received an M.B.A. degree in Administration and Business Management, both from Universidade Salvador - UNIFACS, Brazil. While at MSU she has been involved in many organizations as a volunteer, providing assistance in outreach activities dedicated for young students.

Akshata Kulkarni started her career in polymers in 2012 when she opted for a Bachelor's degree in Polymer Engineering at the Institute of Chemical Technology in Mumbai. During her undergraduate years, she gained hands-on experience in the field through industrial and academic internships, and was chosen as the Summer Research Fellow of the Indian Academy of Sciences in May 2014. At the University of Akron, Akshata is currently pursuing her PhD under the guidance of Dr. Sadhan C. Jana. As a part of her doctoral dissertation, she has worked on developing energy efficient vulcanizing systems for low energy loss tire tread compounds. The work involved using benzocyclobutene based crosslinking agents for obtaining improved properties of the final tread compound, as well as a lower crosslinking time. This project was executed under the aegis of CenTiRe and was a collaborative effort between Dr. Sadhan Jana and Dr. Coleen Pugh from the College of Polymer Science at the University of Akron. Currently, she is working on utilizing highly porous aerogel materials for separating oil-water mixtures. Along with her academic accolades and research experience, she has also served as the President of the Akron SPE Student Chapter during the 2017-2018 academic year. Recently, she also received the Ohio Rubber Group Graduate Student Award as well as the Paul Glasgow Student Scholarship from the ACS Rubber Division. Akshata intends to work in the polymer industry after her graduation.

SPE FOUNDATION

SPE® STILL ACCEPTING DONATIONS FOR DR. JACKIE REHKOPF ENDOWED SCHOLARSHIP

The SPE® Automotive and Composites Divisions, in conjunction with The SPE Foundation®, have formed an endowed scholarship to honor the memory of Dr. Jackie Rehkopf and are still accepting donations. The groups hope to raise funds for a sufficiently large endowment to allow annual scholarships to be given to deserving undergraduate or graduate students studying engineering or science and with plans to work in the field of transportation composites.

Rehkopf spent her career doing research in the field of automotive plastics and composites. She was a long-time SPE ACCE committee member, session organizer, and two-times technical program co-chair. She also served on the SPE Automotive Division board as a director from 2005 through 2014, plus was intersociety chair for 2 years and treasurer for 2 years. She was active from the mid-1990s until 2014 with SAE International®, helping organize a large plastics session for over a decade for SAE Congress. Additionally, she wrote a book in 2011 entitled Automotive Carbon Fiber Composites: From Evolution to Implementation that was published by SAE. She was awarded an SAE Outstanding Technical Contribution Award for her work in co-developing and sponsoring the SAE Standard J2749 High Strain Rate Tensile Testing of Polymers. She authored many publications and presented at numerous technical conferences during her 20 year career.

In both academia and industry, Rehkopf's research interests were in mechanics of materials. After earning both B.S. and PhD degrees in Civil Engineering from the University of Waterloo in Canada, she moved to the Detroit area and began work in 1994 as a materials engineer for Ford Motor Co. After 4 years, she became a technical specialist at Ford in the company's Research Lab Safety Department (from 1998-2003) and later in the Materials Engineering Department (from 2003-2006). She left the automaker in 2006 to join Exponent as a senior engineer and consultant in the areas of mechanics of materials, structural mechanics and dynamics, experimental testing, and failure analysis. Rehkopf's expertise was in high-strain-rate behavior of both metallic and polymeric materials, and fatigue and creep of reinforced and non-reinforced plastics. In 2010, she joined the R&D department of Plasan Carbon Composites as a senior researcher working on carbon fiber-reinforced composites. During her first 2 years at Plasan, she split her time between the company's Customer Development Center in Michigan and offices at Oak Ridge National Laboratory where she was principal investigator for a 3-year U.S. Department of Energy (DOE)-sponsored project that Plasan participated in on predictive modeling of carbon fiber composites in automotive crash. In 2013, Rehkopf became director of research at Plasan with a focus on developing new materials systems to facilitate the use of carbon fiber composites in mainstream automotive applications. She lost a year-long battle to cancer in 2014.

HOW TO CONTRIBUTE

Those interested in contributing to the Dr. Jackie Rehkopf endowed scholarship should send a check (made out to The SPE Foundation) to:

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PLEASE mark in the Notes section of your check that the funds are for the **Rehkopf Scholarship** so they are applied to the correct fund. For more information, call +1 810.814.6412 or email **foundation@4spe.org**. Donations made by U.S. citizens are tax deductible.

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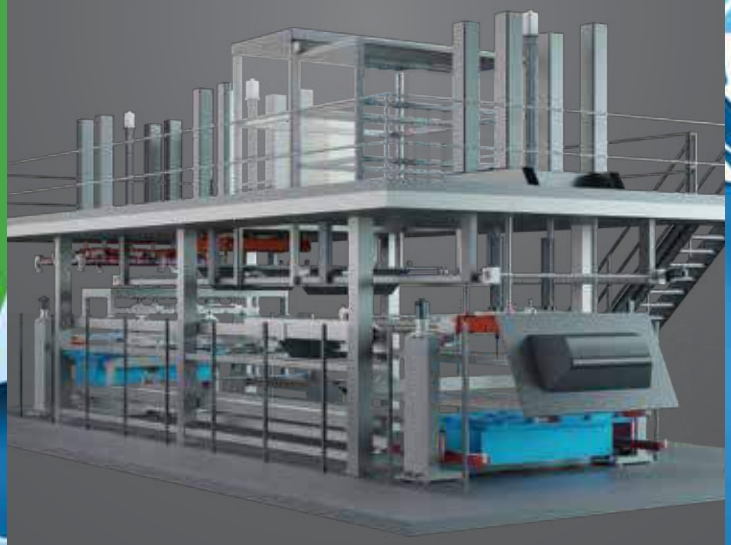

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SPE ACCE Attendees Encouraged to View the Student Posters in the Exhibit Area

Student Program and Competition Judging Sponsored by DuPont and Ford Motor Company

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. This year's competition is our largest one ever with **49 graduate, 23 undergraduate** and **3 high school students** from **29 schools** in the **U.S, Canada, Germany and Turkey** presenting their research at the 2019 ACCE. Please join us in welcoming the students and take a good look at their hard work, which will be on display throughout the conference in Hall C near the Exhibit 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 that will be presented by representatives from DuPont and Ford Motor Company. The awards presentation will take place during a formal recognition ceremony on Friday, September 6th from 1:00 to 2:00 pm in the Diamond Ballroom at the conference.

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 and Alper Kiziltas of Ford.

Topics, student authors, and schools accepted into this year's competition at press time include the following:

STUDENT POSTER ENTRIES

GRADUATE STUDENTS

1 *Bonding of Composite Structures with Additive Manufactured Adhesives,* **Paul Oehlmann**
University of Wisconsin - Madison, MS

2 *Fabrication Method Effects on Mechanical Performance,* **Allen Jonathan Román**
University of Wisconsin - Madison, MS

3 *Petroleum Pitch-based Carbon Fibers with Modified Transverse Microstructure and Enhanced Properties: Fiber Focus,* **Sagar Kanhere, Clemson University, PhD**

4 *Design Optimization for Static and Crash Performance of an Ultra-lightweight Carbon Fiber Reinforced Thermoplastic Composite Vehicle Door Assembly,* **Anmol Kothari**
Clemson University, PhD

5 *Manufacturing Process Effects on Crashworthiness Analysis through a Numerical Simulation Pathway,* **Madhura Limaye, Clemson University, MS**

6 *Parametric Cost Modeling of a Carbon Fiber Reinforced Thermoplastic Composite Vehicle Door Assembly,* **Gaurav Dalal, Clemson University, MS**

7 *Automotive Lightweighting of Class A Panels via Supercritical Foam Injection Molding of Thermoplastic Olefins,* **Sai Aditya Pradeep, Clemson University, PhD**

8* *Measurement and Prediction of Pressure Drop of Nozzle Flow in Fused Filament Fabrication Additive Manufacturing,* **Jingdong Chen, Baylor University, PhD**

9 *Thermoplastic Composites, Testing/Characterization, Modeling and Simulation,* **Kayode Emmanuel Oluwabunmi**
University of North Texas, PhD

10 *Functionalized Alumina Nanofibers Filled Polymer Nanocomposites: Mechanical and Thermal Analysis,* **Harish Sai Prasad Kallagunta**
Texas State University - San Marcos, MS

11 *The Effects of Nanosilica on the Static and Fatigue Properties of Nanomodified Carbon Fiber Reinforced Epoxy Composite,* **O. K. Arigbabowo**
Texas State University - San Marcos, MS

12* *In-Mold Dielectric Analysis During Cure of a Polyurethane-based Sheet Molding Compound,* **Sergej Ilinzeer**
Fraunhofer-Institut für Chemische Technologie, MS

13 *The Effect of the Morphology of Nanoscale Silica Dioxide Structures on the Interfacial Strength of Injection Moulded PPS-metal-hybrids,* **Marcel Laux**
Fraunhofer-Institut für Chemische Technologie, MS

14 *High Performance 3D Printed Continuous Fiber Composites,* **Yu Chao Shih**
University of Alabama - Birmingham, PhD

15 *A New Method for Measuring the Constituent Content of Natural Fiber Composites,* **Yongzhe Yan**
University of Alabama - Birmingham, PhD

16 *Measuring Fiber Length in the Core Layer in Injection Molded Polypropylene Plaques,* **Abrahan Bechara**
University of Wisconsin - Madison, PhD

17* *Sustainable Biocomposites from Biobased Engineering Plastic and Food Industry waste-desired Biocarbon,* **Maisyn Picard, University of Guelph, MS**

18* *Effects of Melt Flow-Fiber Orientation Coupling on Deposition in Large Area Polymer Composite Additive Manufacturing,* **Zhaogui Wang, Baylor University, PhD**

19* *Contribution of Delamination to Impact Damage in Unidirectional Non-crimp Fabric Carbon Fiber Epoxy Composites,* **Aaditya Suratkar, Western University, PhD**

20 *Rapid UV Curing of Automotive Composites,* **Alex Stiles, University of Tennessee, PhD**

21 *Roll Forming of Thermoplastic Composites,* **Saurubh Pethe, University of Tennessee, MS**

22 *Bamboo Fiber-Epoxy Matrix Composite Interphase Modification,* **Mariana Desireé Reale Batista**
Michigan State University, PhD

23 *Void Evolution During Vacuum Bag-only Processing of Composite Prepregs,* **Wei Wu, University of Southern California, PhD**

24 *Preparation of Multi-Particle Polyamide Copolymer Nanocomposite Utilizing a Hybrid Solvent/Melt Compounding Methodology,* **Erik Stitt, Michigan State University, PhD**

25 *Nanoclay as Green Strengthening Agent for Composites Based Cotton Wastes Fibers,* **Areej Almalkawi, Michigan State University, PhD**

26 *Application of Stress Waves for Process Monitoring and Controlling of Induction-based Adhesively Bonded Joints,* **Rajendra Prasad Palanisam**
Michigan State University, PhD

27 *Numerical Simulations of Reversible Adhesive Degradation Due to Electromagnetic Heating,* **Suhail H Vattathurvalappil**
Michigan State University, PhD

28 *Processing Induced Residual Strain Measurements in Dissimilar Bonded Joints,* **Syed Fahad Hassan, Michigan State University, PhD**

29 *Design Guidelines to account for Stiffness Mismatch in Dissimilar Material Bonded Joints,* **Sarat Kundurthi, Michigan State University, PhD**

*presenting author

STUDENT POSTER COMPETITION

STUDENT POSTER ENTRIES

GRADUATE STUDENTS

30 *Effect Bolt Diameter on Efficiency of Hybrid Fastening System,* **Salina Ramli, Michigan State University, PhD**

31 *Novel Composites of Miscanthus-based Biocarbon and Polyphthalamide for Transportation Applications,* **Mateo Gonzalez de Gortari, University of Guelph, PhD**

32 *Poly(3-hydroxybutyrate-co-3-hydroxyvalerate) based Biodegradable Composites for Sustainable Automotive Packaging,* **Kjeld Meereboer, University of Guelph, PhD**

33 *Parameters Optimization of Poly(3-hydrxybutyrate-co-3-hydroxyvalerate) / Poly(lactic acid) for Light-Weight Parts using Fused Deposition Modeling,* **Miguel A. Vigil Fuentes, University of Guelph, MS**

34 *Effect of Crystallization Kinetics on the Residual Stress and Deformation of a Printed Geometry,* **Pasita Pibulchinda, Purdue University, MS**

35* *Improved Parametrization of Topology Optimization for Large-Scale Additive Manufacturing,* **Jack Ramsey, Baylor University, MS**

36* *Investigation of Variations in Closed Cell Foamed Polymer Composite Structures,* **Daniel Pulipati, Baylor University, PhD**

37 *Fiber Aspect Ratio Characterization and Stiffness Prediction in Large-Area, Additive Manufactured, Short-Fiber Composites,* **Timothy Russell, Baylor University, PhD**

38 *Characterizing Hybrid Composites Designed to Increase Light-Weighting in Automotive Composites",* **Nate Blackman, Baylor University, PhD**

39 *An Investigation on Effect of Adhesive Distribution on the Strength of Single Lap Bonded Joints,* **Akash Pisharody, Baylor University, PhD**

40 *Carbon Fiber Orientation Measurements for Large Volume Additive Manufactured Parts Using Optical and Scanning Electron Microscopy,* **Rifat Ara Nargis, Baylor University, MS**

41 *Impedance and Magnetic Non-Contact Based Multifunctional Polymer Sensor Textiles,* **Tonoy Chowdhury, University of North Texas, PhD**

42 *Experiment on Mechanical Properties of Chopped Natural Fiber Reinforced Composite Materials,* **Jingtao Shuang, Baylor University, PhD**

43 *Dual Stopband Filter-based Composite Material Characterization,* **Fares Alharbi, Michigan State University, PhD**

44 *Far Field Microwave NDE System for Inspection of Composites,* **Srijan Datta, Michigan State University, PhD**

45 *Rigid-Flex PCB Based Split-Ring Resonator Sensor for Near Field Microwave Imaging,* **Xiaodong Shi, Michigan State University, PhD**

46 *Sonication of Agave Fiber Bagasse: A Potential Pretreatment to Enhance Sugar Release,* **Cindu Annand, Iowa State University, PhD**

47 *Innovative Crash Box Made by CFRP Using Powder Bed Additive Manufacturing Methodology with Lattice Structure,* **Metin Calli, Uludağ University- Turkey, PhD**

48 *Polyethylene-BN Nanocomposites with Enhanced Thermal and Mechanical Properties,* **Md Golam Rasul, University of Illinois at Chicago, PhD**

49* *Sustainable Hybrid Nanocomposites Based on Recycled Carbon Fibers and Nanocellulose ,* **Ezatollah (Nima) Amini, University of Maine, PhD**

*presenting author

UNDERGRADUATE STUDENTS

1 *Performance of Biocarbon and Graphene Nano-platelets Reinforced Polypropylene Hybrid Composites for Automotive Applications,* **Ethan Watt, University of Guelph**

2 *Sustainable Biocomposites from Nylon 6,6, Soy Hull Biocarbon and Graphene for Automotive and Advanced Engineering Applications,* **Thomas Balint, University of Guelph**

3 *NDE of Lightning Strike Composites,* **Eilish Stanek, University of Tennessee**

4 *Effect of Hole Diameter on Strengths of Fiber Aligned Carbon Composites,* **Benjamin Swanson, Michigan State University**

5 *Additive Manufacturing of Polymer AM,* **Liam Rainer, Pellissippi State Community College**

6 *Sustainable Biocomposites from Bioplastic Blends and Biocarbon,* **Peter Zytner, University of Guelph**

7 *Sustainable Biocomposites from Poly(3-hydroxybutyrate) (PHB) and Agave Fibre: Reactive Extrusion and Performance Evaluation,* **Megan Smith, University of Guelph**

8* *3D Printed Sustainable Biocomposites from a Biobased Engineering Plastic and Biocarbon,* **Elizabeth Diederichs, University of Guelph**

9 *Dynamic Load Testing of PPMC Crush Tubes,* **Federico Tascon, Purdue University**

10 *Parameter Optimization of Optical Microscopy for Determining Elliptical Fiber Orientation,* **Jiasheng Tang, Purdue University**

11 *Petroleum Pitch-based Carbon Fiber with Modified Transverse Microstructure and Enhanced Properties: Composite Properties,* **Caroline Christopher, Clemson University**

12 *Ford Looking To the Trees: Introduction of Nano Cellulose in Flexible Polyurethane Foams,* **Madeline Robison, Michigan State University**

13 *Voids and Other Microscopic Features in 3D Printed Carbon Fiber Reinforced PA12 Composites,* **Elise Kowalski, University of Michigan-Dearborn**

14 *Creating Unique Polymer Composites through Additive Manufacturing,* **Nicholas Ciszewski, University of Michigan-Dearborn**

15 *Generating Automotive Grade Polymer and Composite Materials for Additive Manufacturing,* **Alicia Samson, University of Michigan-Ann Arbor**

*presenting author

16 *Next Generation Hybrid Composites Using Multifunctional Graphene Nanoplatelets,* **Noemie Denis, Florida International University**

17 *Fabrication of Robust Dried (FORD) Silica Aerogels Infused with Graphene,* **Thomas F. Andre, Union College**

18 *Material Properties of Injection Molded Basalt/Hemp Hybrid Fiber Reinforced Polypropylene,* **Kyleigh Rhodes, University of Michigan-Ann Arbor**

19 *Performance Evaluation of Basalt/Hemp Fabric Thermoplastic Hybrid Composite,* **Ian DeBois, South Dakota School of Mines and Technology**

20 *Mycelium-Based Foam from Spent Distiller Grains from Whiskey Industry,* **Rogine Gomez, California State Polytechnic University, Pomona**

21 *Flexible Polyurethane Foam Production with Deep Eutectic Solvent Lignin as a Partial Substitution of Polyol Component,* **Tom Ekstrom, Seattle University**

22 *DES Pretreatment of Corn Stover Hydrolysate to Produce High Purity Lignin,* **Alan Ramirez, University of California, Merced**

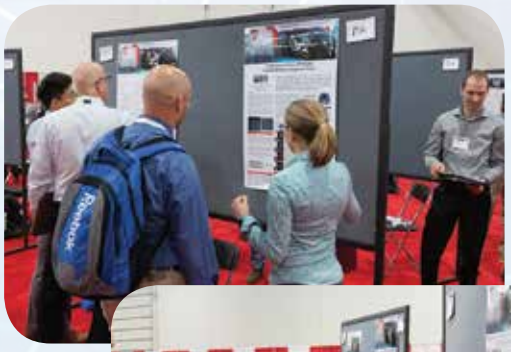
23 *Greener Manufacturing using Bamboo Fiber Composites,* **Xhulja Biraku, University of Michigan-Ann Arbor**

HIGH SCHOOL STUDENTS

1 *Effects of Recycled Polyetherimide (PEI) In Polyurethane Foams,* **Sheila Gubachy, Redford Union High School**

2 *Developing Sustainable Hybrid Thermoplastic Composites Based on Engineered Polysaccharides and Polyamide 6,* **Maxwell Topping, South Lyon East High School**

3 *The Future of the Automotive Industry Is One Atom Thick; Graphene In NVH Foams,* **Tara Ellwood-Mielewski, Rudolf Steiner High School**



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Thermoplastics Composites Conference
Location TBD · April 2020

Infrastructure Fly-In
Washington, DC · April 2020

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Developing bio-based feedstocks for additive and composite manufacturing

A research collaboration between Oak Ridge National Laboratory (ORNL) and the University of Maine (UMaine) launches the first large-scale bio-based additive manufacturing program in the US, connecting regional industry and university clusters with national lab resources.

Funded by the Department of Energy's Advanced Manufacturing Office, the collaboration provides students, faculty and companies associated with UMaine's Advanced Structures and Composites Center with access to ORNL's assets in advanced manufacturing at DOE's Manufacturing Demonstration Facility (MDF). ORNL researchers will gain access to UMaine's expertise in cellulose nano fiber (CNF) and composites.

Research and Development

Fundamental research—Research teams will study key technical areas including CNF production, drying, functionalization, compounding with thermoplastics, multiscale modeling and sustainability life-cycle analysis.

CNF innovation—By placing CNF into plastics, strong, stiff, and recyclable bioderived material systems can be developed.

3D printing—Material systems can be printed at deposition rates of hundreds of pounds per hour and up to 50 percent cellulose fiber loading.

Market advancement—Printing with 50 percent wood opens up new markets for pulp, paper and forest products industries.

Renewable feedstock—CNF could rival steel properties and successful incorporation into plastics shows great promise for additive manufacturing.

ENABLES regional industries to rapidly deploy technologies

STRENGTHENS US competitiveness in advanced manufacturing

ENVISIONS working with industry to produce new bio-based feedstocks

SUPPORTS 3D printing of boat molds, shelters, building components, tooling for composites, wind blades

POSITIONS industry to print large, structurally demanding systems (boats)

PREPARES the workforce of the future

3D printed large-scale boat mold from bioderived materials

Contacts

Oak Ridge National Laboratory

Craig Blue, PhD
Program Director, Energy Efficiency & Renewable Energy
blueca@ornl.gov

University of Maine

Habib Dagher, PhD, PE
Executive Director, Advanced Structures and Composites Center
hd@maine.edu

Oak Ridge National Laboratory
1865 The University of Maine
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SPE® ANNOUNCES 2019 AUTOMOTIVE COMPOSITES CONFERENCE & EXHIBITION (ACCE) BEST PAPER AWARD WINNERS

The 2019 SPE ACCE Best Paper Award winners received the highest average ratings by conference peer reviewers out of a field of close to 100 contenders. All three winners will be honored for excellence in technical writing, with a commemorative plaque, during the SPE ACCE opening ceremonies on Wednesday morning, September 4th.

Sara Andrea Simon, a PhD candidate at the Polymer Engineering Center (PEC), University of Wisconsin-Madison (Madison, Wisconsin, USA), won first place in this year's competition; **Dr. Xiaoming Chen,** a Technical Expert at Ford Motor Company (Dearborn, Michigan, U.S.A.), won second place; and **Dinesha Ganesarajan**, a graduate student working on his Master of Science degree in the Chemical Engineering department at the University of Waterloo (Waterloo, Ontario, Canada), placed third in the competition.

Sara Andrea Simon won first place for her paper titled ***Direct Fiber Model Validation: Orientation Evolution in Simple Shear Flow.*** The paper will be presented on **September 4th** from **1:00 to 1:30 PM** in the **Advances in Thermoplastic Composites** session at the conference. About this topic, the author says, "The ability to simulate the processing of fiber reinforced composites has become indispensable for the automotive industry. Particle level simulation, in specific, is a promising tool that can be employed in the improvement of commercial software. In this work, reliable fiber orientation evolution data was obtained to aid in the validation and development of our particle modeling approach for reinforcing fillers."

Simon is a PhD candidate at the Polymer Engineering Center (PEC), University of Wisconsin-Madison. She currently works in collaboration with Volkswagen on a new physical foaming injection molding technique to advance lightweight automotive constructions. Simon holds a Master of Science degree in Mechanical Engineering as well as a Master of Science degree in Natural Sciences. Her research interests focus on characterization and simulation of discontinuous fiber composites. In the past three years at the PEC, Simon investigated fiber breakage, fiber-matrix separation and fiber orientation during mold filling.

INSPIRE

Dr. Xiaoming Chen won second place in the competition for her paper titled ***Fatigue and Strength CAE and Test Results.*** She will present her paper on **September 6th** from **10:30 to 11:00 AM** in the **Opportunities and Challenges with Carbon Composites** session at the conference. About her topic, Chen explains "The carbon fiber composite subframe design was CAE driven. The performance of the prototype subframe was verified by component and vehicle tests. The CAE predictions for the tests had various degrees of correlation with the physical test results."

Chen is a Technical Expert at Ford Motor Company. She holds a PhD in Mechanical Engineering from Northwestern Polytechnical University in China and is an Alexander von Humboldt fellowship recipient. Chen started her career as a crash safety engineer at Ford Truck Operations and later joined the Lightweight Architecture Team of Research and Advanced Engineering. She was the lead engineer for the crash safety development of an aluminum intensive passenger car, the Ford GT magnesium cross car beam, and an advanced high strength steel body side design using hydro forming technologies. Her current projects are related to lightweight chassis systems and components using advanced high strength steel, aluminum, magnesium and composites materials.

Third place winner, **Dinesha Ganesarajan's** paper is titled ***Latest Breakthroughs with Hybrid Reinforced Composites in Lightweight Applications.*** Dr. Leonardo Simon, University of Waterloo and ACCE Technical Program Co-Chair, will present his paper on **September 5th** from **10:30 to 11:00 AM** in the **Sustainable Composites** session at the conference. About his research, Ganesarajan comments, "My work explores the utilization of hybrid composites in the automotive industry for body interior and under the hood applications. The use of naturally-sourced filler material with the combination of glass fiber yields superior performance properties with a lightweighting initiative. This is a necessary intermediate step to achieve the ambitious goal of a circular economy just like the introduction of hybrid vehicles before the emergence of electrification."

Ganesarajan is a graduate student pursuing a Master of Science degree at the University of Waterloo's Chemical Engineering department. His thesis topic explores the use of naturally sourced filler materials being combined with glass fiber to produce hybrid composites for body interior and under-the-hood applications in the automotive industry. He completed his undergraduate program at the University of Waterloo majoring in Chemical Engineering with an energy systems specialization.

Ganesarajan has four years of industry experience having worked at companies like Tesla Motors, Ford Motor Company, Ballard Power Systems, and Northern Cables. His expertise is in materials science and his passion is in sustainability and achieving a "circular economy".

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