SPE COMPOSITES

WINTER 2022

Composites Connection™

Official Newsletter of the SPE Composites Division

Reaching Over 1,000 Composites Professionals
In All Industries

Board of Directors

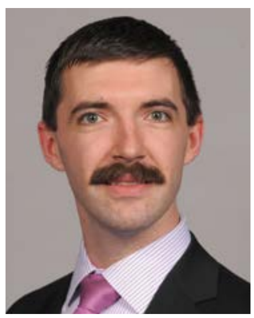
John P. Busel, F. ACI
SPE Composites Director,
Chair & Intersociety Chair
V.P. Composites
Growth Initiative
American Composites
Manufacturers Association
Arlington, VA
jbusel@acmanet.org

Oleksandr G. Kravchenko, Ph.D.
SPE Composites Director,
Chair-elect, ACCE Technical
Program Co-Chair, &
Assistant Professor,Dept.
of Mechanical and
Aerospace Engineering
Old Dominion University
Norfolk, VA
okravche@odu.edu

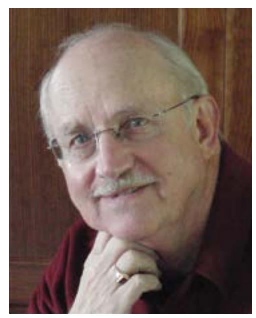
Mingfu Zhang, Ph.D.
SPE Composites
Director & Treasurer
Johns Manville
Research Manager,
Corporate R&D
Littleton, CO
mingfu.zhang@jm.com

Christoph Kuhn
SPE Composites Director
& Secretary
Volkswagen
Group Research Materials &
Manufacturing Methods
Wolfsburg, Germany
christoph.kuhn@vw.com

Dale Brosius
SPE Composites Director
& Councilor
Chief Commercialization
Officer, IACMI
Knoxville, TN
dbrosius@iacmi.org



Ian Swentek, Ph.D.
SPE Composites
Past Chair,
Applications Development
Engineer Hexion
London, ON, Canada
Ian.Swentek@hexion.com



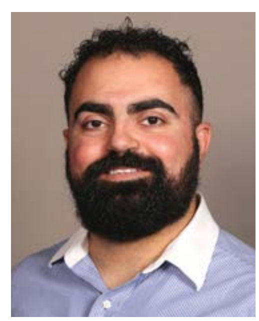
Daniel T. Buckley
SPE Composites
Director (Retired)
Emeritus Director
dbuck@vermontel.net

Rich Caruso
SPE Composites Director
CEO Inter/Comp LLC
Falmouth, MA
rpcaruso@gmail.com

Michael Connolly, Ph.D.
SPE Composites Director
Technology Leader -
Composites
Composties Huntsman
Polyurethanes
Auburn Hills, MI
michael_connolly@huntsman.com

Pritam Das
SPE Composites Director
& Newsletter Chair
Senior Technical Manager
Toray Composites
Materials America (CMA)
Tacoma, WA
pdas@toraytca.com

Frederick S. Deans
SPE Composites Director
Principal
Allied Composite
Technologies, LLC
Rochester Hills, MI
fdeans@alliedcomptech.com



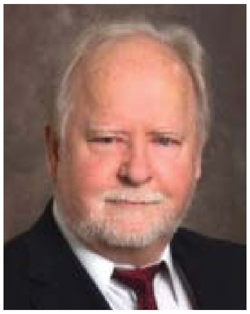
Hicham Ghossein, Ph.D.
SPE Composites Director
& Award Chair
President & Founder
of Endeavor
Hicham.ghossein@gmail.com

SPONSOR LINKS

BASF We create chemistry
BYK
carbon conversions closing the loop - today and tomorrow
DSC CONSUMABLES incorporated
HEXION Responsible Chemistry
MICHELMAN
MITSUBISHI CHEMICAL
Moldex3D MOLDING INNOVATION
MP Molding Products
Mitsui Chemicals Group
سابك sabic


BASF
We create chemistry
IDEAL
Engineering plastics and polyurethanes by BASF for the automotive industry
We turn your ideas into ideal solutions: BASF plastics for the automotive industry.
Shorter development times, enhanced performance, greater freedom in design. You do not want to settle for anything less than the perfect car. Neither do we. That is why we will stay by your side at every stage of your project - with our comprehensive expertise in plastics and application development, individual parts testing, consultancy in design, simulation and much more - available to you around the world. When your idea turns into the ideal car, it's because at BASF, we create chemistry.
www.performance-materials.basf.com

Board of Directors continued...



Jack Gillespie, Ph.D.
SPE Composites Director
Director, Center for Composite Materials
Donald C. Phillips Professor of Civil and Environmental Engineering
University of Delaware
Newark, DE
gillespi@udel.edu

Jim Griffing
SPE Composites Director & SPE Past President
Boeing (Retired)
Seattle, WA
jsgriff1@gmail.com

Enamul Haque, Ph.D.
SPE Composites Director
A2H Consulting Group
Enamul.Haque@a2hconsultinggroup.com

Antoine Rios, Ph.D.
SPE Composites Director, Finance Chair,
The Madison Group
Madison, WI
Antoine@madisongroup.com

Khaled W. Shahwan, Ph.D.
SPE Composites Director
Sr. Technology Leader - Composites, Methods & Strategies,
Global Automotive Research & Advanced Engr., Chrysler Technology Center
Auburn Hills, MI
khaled.shahwan@stellantis.com

Shankar Srinivasan, Ph.D.
SPE Composites Director & ANTEC Program Chair
Iowa State University
Economic Development Core Facility
Ames, IA
srigshan@iastate.edu

Uday Vaidya, Ph.D.
SPE Composites Director & Education Chair
Professor in Mechanical, Aerospace & Biomedical Engineering
Chief Technology Officer (CTO), IACMI
University of Tennessee
Knoxville, TN
uvaidya@utk.edu

Pritesh Yeole, Ph.D.
SPE Composites Director
Research Associate in Advanced Composites Manufacturing
Fibers and Composites Manufacturing Facility
University of Tennessee Knoxville
pyeole@vols.utk.edu

This Issue:

See page 20 for more details


carbon conversions
closing the loop - today and tomorrow
The Evolution of Recycled Carbon Fibers
introducing
the re-Evo® brand of products
Including our chopped carbon fiber
and non-woven advanced materials.
Find out more at CarbonConversions.com • 843-374-5600

By: Eve Vitale

Find, Focus, and Flourish:

How the SPE Foundation is Working to Solve our Industry's Workforce Shortage

By Eve Vitale,
SPE Foundation Chief Executive

Picture yourself comfortably retired on your 65th birthday which is coming up later this year. It's time for you to finally take a breather from your demanding, yet exciting career in our beloved industry. Sure, there's social security, but what other resources will you need to live the lifestyle you want? My guess is you haven't waited until the last moment to start investing. Finance doesn't work that way. If you want to reap the rewards of a great investment strategy, then you know you must start early – the earlier the better.

It's the same with workforce development. I get calls and emails quite frequently from folks who are looking for solutions to their lack of qualified or even interested workforce. This is only exacerbated by the great resignation we're experiencing in the U.S. What I tell the frantic manager or business owner is that the SPE Foundation cannot churn out solutions (people) on demand – it takes time and investment. And that means we must look beyond the next quarter.

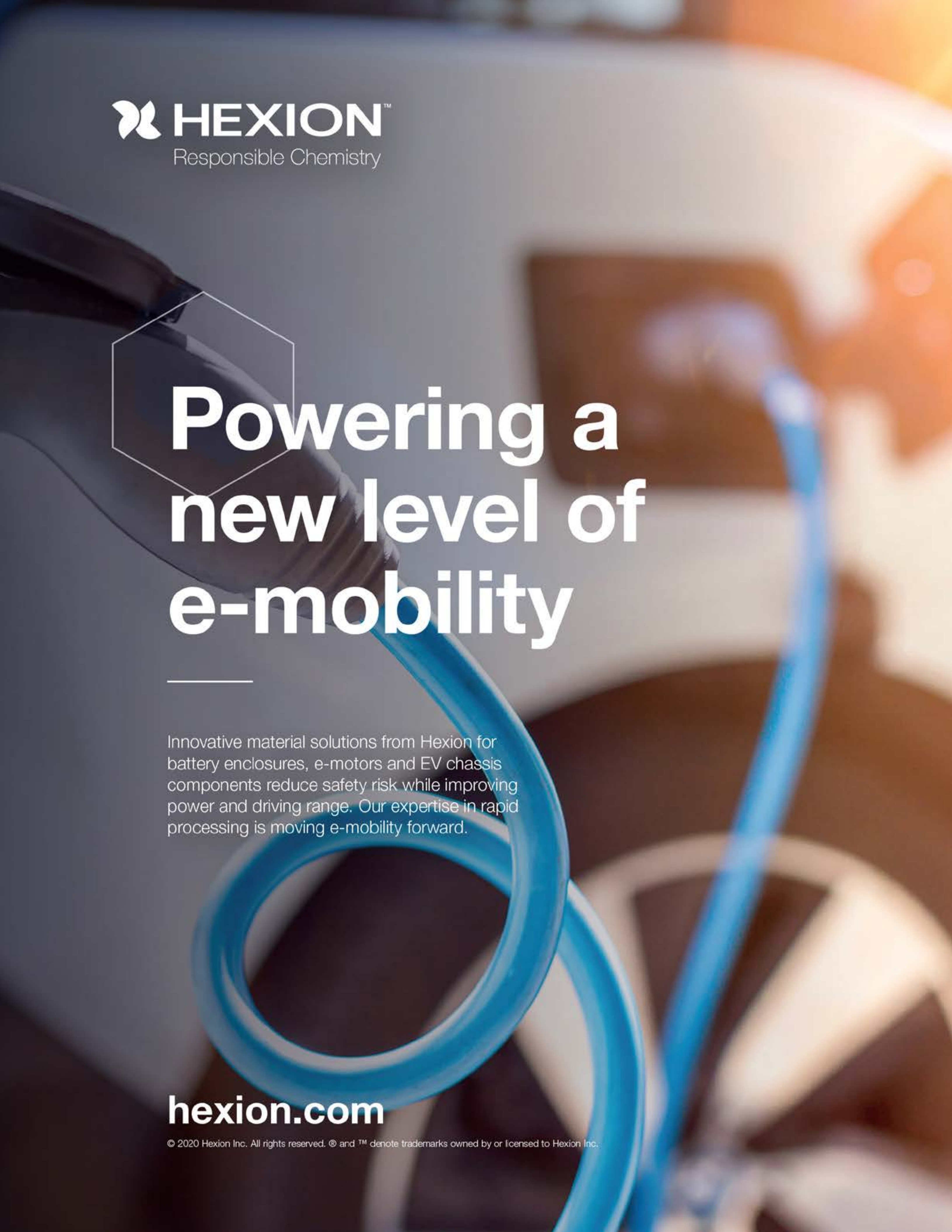
So that's what we're doing at the SPE Foundation. We're investing in students early and often. Our new programming has been developed with key performance indicators (KPIs) which will lead to a strong return on investment (ROI) – more plastics workforce. Think of it as a start-up and this is our collective opportunity to invest.

The SPE Foundation set out to FIND students, FOCUS on quality plastics education, and watch young minds FLOURISH.

continued on page 8...

SPE STEM Club – Modeling polymer chains.

This Issue:


HEXION™
Responsible Chemistry
Powering a new level of e-mobility
Innovative material solutions from Hexion for battery enclosures, e-motors and EV chassis components reduce safety risk while improving power and driving range. Our expertise in rapid processing is moving e-mobility forward.
hexion.com
© 2020 Hexion Inc. All rights reserved. ® and ™ denote trademarks owned by or licensed to Hexion Inc.

Plastivan Program continued...

We FOUND community partners and schools that were interested in what we had to offer – an after school SPE STEM Club to FOCUS on supporting students' Science, Technology, Engineering and Mathematics learning through positive plastics education.

We utilize the PlastiVan® curriculum. This weekly programming with students is enhanced with all-school access to our PlastiVideos™ which were developed in 2020 to support continued plastics education in pandemic-learning conditions. We also deliver school-wide Plastics STEM Days which engage all students and faculty in the science and engineering of plastics. Schools also have access to an annual "Wonders of Plastics" essay contest and are encouraged throughout the year to ask questions about plastics, polymers, composites, sustainability, and innovation and to craft an essay answering those questions. This gets them engaged in investigation and critical thinking. Last year we had middle school entries on "Bioplastics and Artificial Limbs," "Using Chemistry to Make Plastics Biodegradable," "Recycling Marine Fishing Nets," and high school entries on "Plastics in a Pandemic – Protecting Lives Every Day," "Pyrolytic Gasification," and "3D Printing on the International Space Station."

There is also a Polymer Science Fair component. This is the standard science fair competition with posters and displays and a chance for students to present on the topic of their choice. Last year we had entries in 3D printing of electric vehicle charging adapters and using bioprinting technology to produce micronutrients to combat malnutrition in Zimbabwe, to name a few.

We encourage industry field trips and participation in SPE conferences. Although we continue to be hampered by the latest COVID surges, 15 Detroit students were able to attend the SPE Automotive Composites Conference and Exhibition in Novi, MI in 2020. They participated in the PlastiVan program, interacted with grad students and their research posters, talked with exhibitors, and attended a panel discussion about careers and the business of composites in the automotive industry.

continued on page 9...

Arkema Junior Researcher, Jonathan Bryant

Project: 3D Printing of Electric Vehicle Charging Adapters

This Issue:

Plastivan Program continued...

Young scientists and engineers get the chance to become a researcher at one of Ecotek Science at Work! Labs. This is a year-round extracurricular activity giving students the chance to excel in science and engineering through weekly practice in a lab setting. Many student projects focus on polymeric materials. Through a partnership with Arkema, students in the 8th-12th grades are eligible to apply for an Arkema Young Researcher Award. This $500 research stipend helps students fund project development and teaches them how to manage "grant" funding. Arkema is also funding college scholarships for select students who will be seeking a degree that is beneficial to a plastics career.

Through these activities we now watch young minds FLOURISH. Students who might otherwise never see themselves as scientists or engineers become accustomed to mastering STEM knowledge and then sharing that comprehension through essays, projects and even teaching peers. Observing this has been my greatest delight in this work we're doing.

In December I had the pleasure of witnessing 7th and 8th grade STEM Club participants teaching their classmates and some high school students what they were learning. Twenty American International Academy students from Inkster, MI worked several tables demonstrating the cool tricks of polymer sci-

continued on page 10...

Plastivan Program continued...

ence and 3D printing. At first, they seemed nervous, but as we all know, teaching is one of the best ways to learn. By the end of the event, they had become experts by fielding questions, coming up with clearer explanations, and sharing their grasp of scientific and engineering principles. It was inspiring to watch. This equal access to STEM educational experiences will help these students lay claim to their abilities and if they so desire, become plastics professionals. We are privileged to partner with the families, schools, and community leaders so we can witness this flourishing of young minds and spirits.

The SPE Foundation has made a 10-year commitment to these programs. Remember – it's an investment strategy. We are currently in Michigan and Florida serving thousands of students and have plans to expand to Texas in 2022. We're capturing data to help us on our journey of continuous improvement and impact. We are also looking for corporate and SPE Chapter partners. That's where YOU come in.

To make a difference we need to work together, pooling our resources of time, talent, and dollars. If you would like to learn more about virtual mentoring, judging the "Wonders of Plastics" essay contests, judging the Polymer Science Fair, inviting students to see your lab or shop, becoming a corporate or chapter sponsor of this impactful programming, or you just want to share your ideas about how we can support plastics workforce, please reach out to me directly at evitale@4spe.org | +1 810.814.6412

Materials. Process. Design.
Building Lighter and Safer Cars for Tomorrow.

Forged Molding Compound
The NEW Look of Carbon Fiber
Carbon Fiber Thermoset Composites

SymaLITE®
Low Weight Reinforced Thermoplastics (LWRT) Composite Materials

KyronMAX™
Advanced Chopped Carbon Fiber Engineering Thermoplastic Compounds: PA, PPA, PPS, PEI, PEAK, PAEK

GMT
Glass Mat Reinforced Thermoplastics

GMTex®
Structural Thermoplastic Composite Materials

FUNCSTER™
Long Glass Fiber Polypropylene Composites

MITSUBISHI CHEMICAL ADVANCED MATERIALS | MITSUBISHI CHEMICAL CARBON FIBER AND COMPOSITES | GEMINI | MYTEX POLYMERS High Performance Polymers Worldwide

Mitsubishi Chemical and our group companies are dedicated to the automotive industry, with R&D and growth in high performance composites aimed at interior, exterior and functional applications. Our focus is on developing and bringing to market lightweight, sustainable, high value and premium asthetic solutions. Look to Mitsubishi Chemical for the ultimate in range, innovation and value.

MITSUBISHI CHEMICAL

mitsubishi-chemical.com

ACCE Conference Report

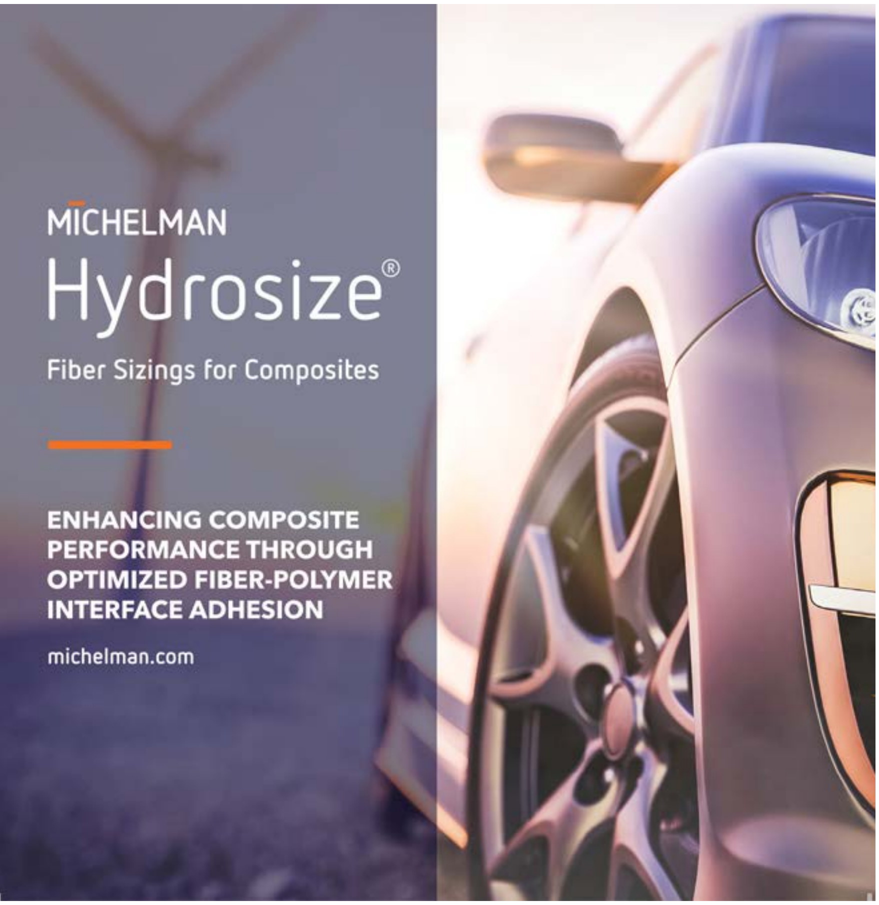
SPE Automotive Composites Conference & Expo (ACCE) Was A Success!

Attendees Were Happy to be Back Networking In Person Again

60 Technical Presentations, 35 Student Posters, 52 Sponsors, 35 Exhibits, 3 Keynotes

TROY (DETROIT), MICH. - The 21st annual SPE® Automotive Composites Conference & Expo (ACCE), produced by SPE's Automotive and Composites Divisions, was a success according to sponsors, exhibitors, and attendees.

"It was great to be back networking again in person," said Raymond Curtice – Engineering Manager of ProtoLAB at Baylor University. "The attendees are motivated to learn how composites technologies will help their business and they are the 'movers and shakers' in the industry – the kind of people we want to meet and get to know, continued Curtice.



"Once again, the entire event was excellent in terms of content, organization, and value, said Erik LaBelle – Automotive Technical Business Development Specialist at 3M.

"SPE ACCE is the best conference for educating the industry and academia about the design versatility structural strength, sustainability and lightweighting performance benefits of composites material technologies for advancing innovative applications," said Dr. Alper Kiziltas – Technical Expert at Ford Motor Co.

"Congratulations to the ACCE Team for persevering through COVID-19 challenges and producing a successful in-person event important for the industry and student opportunities," added Kiziltas.

The ACCE event was held November 2 – 4, 2021 at the Suburban Collection Showplace Diamond Banquet and Conference Center in Novi, Michigan. The SPE ACCE is known as "The World's Leading Automotive Composites Forum." ACCE's goal is to educate the global transportation industry about the benefits of polymer composites in vehicle design and manufacturing for reducing mass, improving performance, lightweighting, and more.

continued on page 13...

ACCE Conference Report continued...

The ACCE 2021 event attracted 450 registered attendees

including automotive OEMs, tier suppliers, academic faculty and students, and other industry professionals. The technical program included 60 presentations on the latest advancements in thermoplastics and thermoset composites; enabling technologies, additive manufacturing, carbon composites and reinforcements; modeling; sustainable composites; business trends and technology solutions; and bonding, joining and finishing.

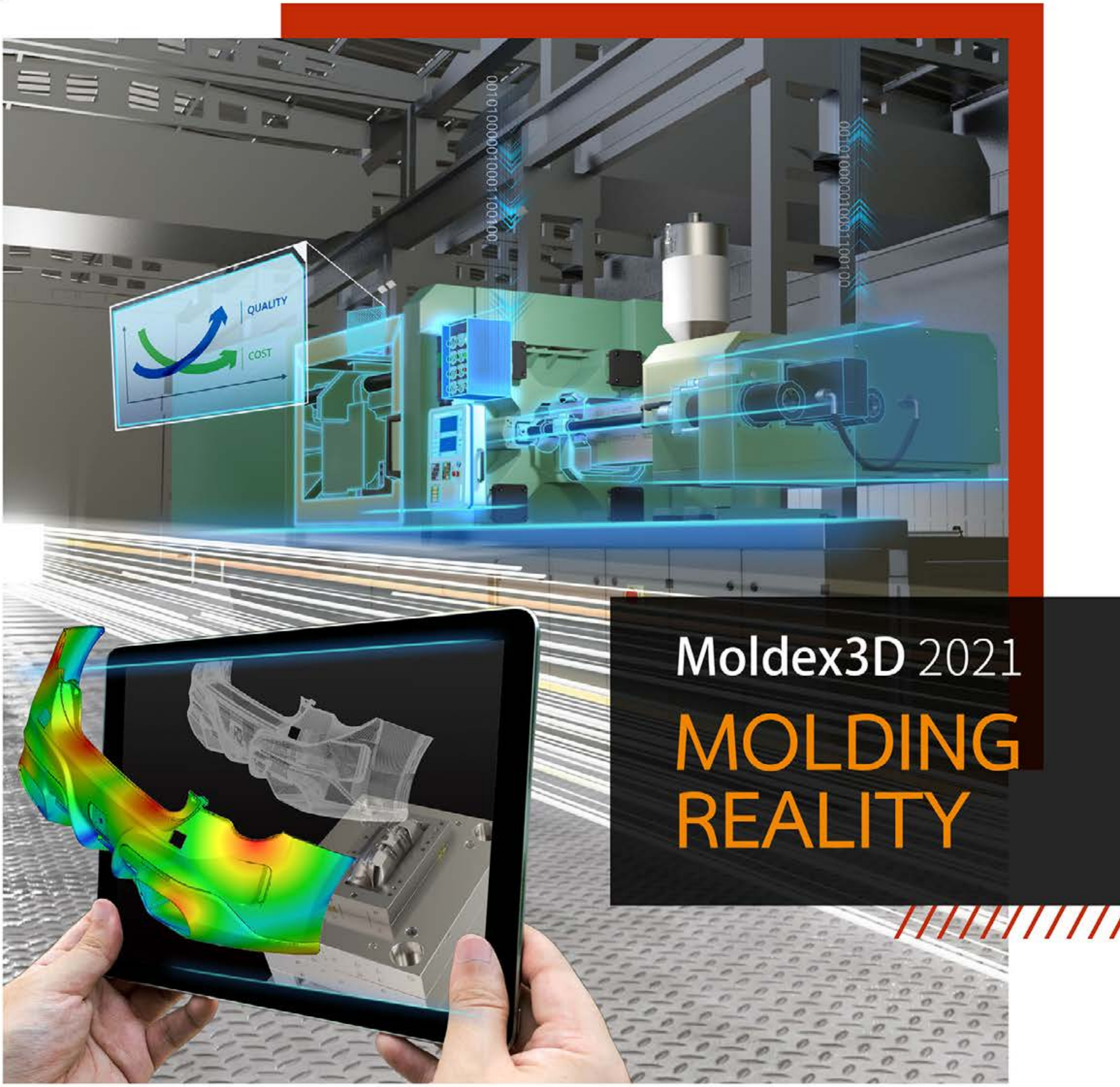
Three presenters were honored at the event with Best Paper awards. Three keynotes were featured and a panel discussion with industry leaders was also included. The Student Poster Competition included 35 posters illustrating composites research projects from 13 universities from the United States and Canada. Ten students received awards for having the best posters in a variety of categories. Scholarships were awarded to four students who demonstrated scholastic excellence in composites engineering and related studies and promise for the future. The annual ACCE Part Competition included 5 nominations for material innovations in prototype and production parts. Awards were presented for most innovative prototype and production parts, selected by industry experts, and a "People's Choice award was also presented. Sponsorship included 35 exhibitors displaying the latest composites technologies and 7 companies sponsoring breakfasts, coffee breaks, lunches, receptions and advertising. Ten leading automotive, plastics and composites media publications supported the event with advertising worldwide.

The 2021 ACCE was led by

2018, 2019 and 2020 ACCE Technical Program co-chair Dr. Leonardo Simon, professor, Chemical Engineering at University of Waterloo; returning ACCE 2020 co-chair Dr. Xiaosong Huang, lab group manager of Polymer Composite Systems in GM Global Research & Development, General Motors Company; and Dr. Khaled W. Shahwan, senior technology leader – Advanced Technology & Pre-Development Programs, Stellantis. The technical program was cochaired by Dr. David Jack, professor, Mechanical Engineering at Baylor University; and Dr. Oleksandr G. Kravchenko, assistant professor, Composites Modeling and Manufacturing Group, Department of Mechanical and Aerospace Engineering at Old Dominion University.

continued on page 15...

This Issue:



Moldex3D 2021 brings you unmatched molding reality

In a fast-changing market, you always need to stay a few steps ahead of the competition. Moldex3D 2021 helps you do just that by providing true injection molding simulation. With great prediction accuracy and ease of use, Moldex3D 2021 can detect molding defects in early development stages and validate your product designs, making sure your products come out the way you want it, and even better.

Realize your first-time-right designs by scheduling an online demo by scanning our QR code.

Moldex3D

ACCE Report continued...

Keynotes:

The first keynote of the conference, "Advancements for Cost-Effective Resin Systems and Composite Applications," was delivered by Dan Dowdall, Global Business Development Manager-Transportation Composites, INEOS Composites. His presentation outlined INEOS Composites' resin systems for value-driven composites and highlighted recent and potential product applications. "As auto/truck OEMs and mobility suppliers move in dramatic new directions, one requirement has remained constant – design and material decisions must be cost-effective," said Dowdall. "Polymer composites are the material of choice for design flexibility, reducing weight and improving performance in automotive applications," continued Dowdall. "However, historically composites were used mainly in lower production applications such as high-performance racing and luxury sports cars due to higher costs associated with composites technologies," added Dowdall. "Now, composites are also meeting the challenge of being cost-effective making them more practical for high volume automotive production applications which will revolutionize the industry."

The second keynote of the conference, "Rassini's Innovative Journey to HP-RTM Manufacturer," was presented by Brent Collyer, VP Engineering, R & D Director Lightweighting, Rassini International Inc. His presentation outlined the design and implementation of North America's first high volume HP-RTM (High Pressure – Resin Transfer Molding) process for composites automotive parts.

"Rassini substituted spring steel with GFRP (Glass Fiber Reinforced Plastic) using a thermoset resin system from Hexion to produce a multi-material (plastic and steel) leaf spring and achieved a 30% weight savings per component compared to an all-steel component" said Collyer. "Equal to or better performance criteria for the suspension system was achieved," continued Collyer. Rassini is a world leader in automotive suspension producs for global OEMs and now the first company in North America to commercially mass produce HP-RTM GFRP suspension components for a high volume light duty truck in North America.

The third keynote, "IACMI: A National Asset and What Comes Next," was presented by John Hopkins, CEO, IACMI (Institute for Advanced Composites Manufacturing Innovation). His presentation outlined how IACMI, from its inception in 2015, has

continued on page 16...

been focused on helping industry transition technologies from laboratory scale to full production. IACMI has facilitated the creation of the largest collection of open-access composites facilities at relevant scale supported by leading universities and national labs. This has resulted in the commercialization of dozens of new products, the lowering of cycle times and costs, improving simulation tools, and advancing recycling technologies. IACMI's workforce development successes are recognized nationally, preparing the next generation of technicians, scientists and engineers for the composites industry. The presentation highlighted challenges and future opportunities and how IACMI is addressing them.

Panel Discussion:

The ACCE 2021 event also included a panel discussion, "Driving Value in Automotive Composites Manufacturing," moderated by ACCE Lead Chair Dr. Leonardo Simon, Professor of Chemical Engineering, University of Waterloo. The panelists included: Dan Dowdall, Global Business Development Director, INEOS Composites; Dale Brosius, Chief Commercialization Officer for the Institute for Advanced Composites Manufacturing Innovation (IACMI); Hugh Foran, Executive Director, Teijin Automotive Technologies (formerly Continental Structural Plastics/CSP); and Steve Eynon, Advanced Engineering Development Lead, Stellantis. The panel of industry experts noted how value in automotive composites manufacturing is

continued on page 17...

ACCE Conference Report continued...

driven by automotive consumer perceptions, OEM and tier supplier innovations and industry collaborations advancing the industry via trade associations, conferences and events.

ACCE: Nathaniel Blackman, Baylor University Wins Best Paper Finalist Award

Best Paper Awards:

To honor excellence in technical writing, those presenting the best papers are recognized annually at ACCE. The Best Paper Award winners received the highest average ratings by conference peer reviewers out of a field of close to 60 contenders. The ACCE 2021 Best Paper Award Winners are:
Rebecca Cutting and co-authors, from Purdue University, for her paper, “Physics-Based Simulation/Workflow for Stamp Forming of Thermoplastic Parts”; Nathaniel Blackman and co-authors, from Baylor University for his paper, “Efforts Toward Automated Foreign Object Detection of Carbon Fiber Laminates Using Pulse Echo Ultrasound”; and Chinmoyee Das and co-authors, from Michigan Technological University for her paper, “Development of Electrically Conductive Composites of Nylon 12 by Incorporation of Biocarbon Filler.”

Student Poster Competition:

Every year at ACCE, students from the U.S.A. and international universities present their innovative research related to plastic composites materials and manufacturing technologies relevant to automotive applications. This annual event is a great opportunity for the students to interact with members of the automotive composites industry and learn about what it is like to work as a scientist or engineer in the field. OEMs and tier suppliers benefit being able to meet the next generation of automotive composites engineers and scientists and potentially hire them. The ACCE 2021 Student Poster Competition included 35 posters from 13 different universities in the United States and Canada. The 2021 ACCE Student Poster Competition winners are:

Undergraduate Category

1st Place: “Low Cost Carbon Fibers from Lignin Precursors for Automotive and Ablative Composites” Elijah Taylor, Clemson University

continued on page 18...

Dr. Leonardo Simon, ACCE Chair, presents Chinmoyee Das with ACCE Best Paper Award

This Issue:

ACCE Conference Report continued...

Dr. Leonardo Simon presents Sara Andrea Simon with Dr. Jackie Rehkopf 2021 graduate Scholar Award

Runner-up:

"Development of Innovative Filament Wound Systems for Automotive & Truck Applications" Nicholas Martin, University of Tennessee

Runner-up:

"Mechanical Behavior of Short Pitch Based Carbon Fiber Reinforced PA66 Polyamide Composites Using Wet-Laid Technique" Tyler Sundstrom, University of Tennessee

Masters Category
1st Place:

"Wide Carbon Tow Thermoplastic Melt Impregnation Development and Applications" Benjamin Schwartx, University of Tenessee

Runner-up:

"Study of the Properties of Polypropylene Based Wood Plastics Using Two Different Wood Fillers: Wood Flour and Wood" Geeta Pokhrel, University of Maine

Runner-up:

"Composites Innovations for Lightweight Bicycles" Ryan Ogle, University of Tennessee

PhD – Nondestructrive Evaluation & Characterization Category
1st Place:

"Mechanical Testing of Induction Bonded Joints With and withoutGuided-Wave Controlled Processing" Rajendra Plainsman, Michigan State University

2nd Place:

"Determination of Ply Stack in Plain Weave Carbon Fiber Composites Using High-Frequency Pulse Echo Ultrasound" Nathaniel Blackman, Baylor University

3rd Place:

"Effect of Platelet Length and Stochastic Morphology of Flexural Behavior of Prepreg Platelet Molded Composites" Siavash Sattar, Old Dominion University

PhD – Nano, Bio, Additive Manufacturing Category
1st Place:

"Novel Microcellular Injection Molding Technology Ku-Fizz™ – Effect of Gas Pressure on the Fiber Microstructure and Flexural Properties" Sara Simon, University of Wisconsin

continued on page 19...

Dr. Leonardo Simon presents Laura Slann with Dr. Jackie Rehkopf 2021 graduate Scholar Award

This Issue:

ACCE Conference Report continued...

2nd Place:
"Multiphysics and Multiscale Modeling of AM Printed Parts" Sarachandra Kundurthi, Michigan State University

3rd Place:
"Effects of Midplane Carbon Nanotube Sheet Interleave on the Strength and Impact Damage Resistance of Carbon Fiber Reinforced Polymer Composites" Amir Nasirmanesh, Baylor University

PhD – Processing, Modeling & Simulation Category
1st Place:
"Fiber Dispersion Characterization Method via X-ray Imaging – Couetter Flow Predicion Using Artificial Intelligence" Allen Roman, University of Wisconsin

2nd Place:
" The Effect of Fiber Biundle Morphology on Dispersion for Long Fiber-Reinforced Thermoplastics" Hector Perex, University of Wisconsin

3rd Place:
"GUI Developoment for Composite Laminate Property Computation Using MATLAB App Designer" Victor Mota, Baylor University

Scholarship Awards:
This year's ACCE Scholarship was named in honor of the late Nippani Rao – a long time ACCE supporter/volunteer and member of the SPE Automotive and Composites Div. Board of Directors. The winner of the SPE ACCE scholarship ($2,000 USD), named in honor of Nippani Rao, is Jomin Thomas, a PhD candidate pursuing a doctoral degree in Polymer Engineering at The University of Akron. The two winners selected for this year for the Dr. Jackier Rehkopf Scholarship ($2,500 USD each) were Lauren Slann, a graduate student pursuing a Master of Science degree in Automotive Engineering at Clemson University and Sara Andrea Simon, a PhD candidate pursuing a doctoral at the Polymer Engineering Center (PEC) at the University of Wisconsin – Madison.

Part Competition:
This year's ACCE Part Competition included 5 nominations. A panel of 13 automotive composites industry experts, from industry and academia, studied the nominations in advance of the event and reviewed the parts onsite and voted for the most innovative material applications in 2 categories (Most Innovative Production Part and Most Innovative Prototype Part). Nominations were judged on the impact and trendsetting nature of the application, including materials of construction, processing methods, assembly methods, and other enabling technologies that made the application possible. Nominations emphasized the benefits of design, weight and cost reduction, functional integration, and improved performance. A separate prize, the People's Choice award, was selected by vote of conference attendees. Here are the winners:

continued on page 20...

This Issue:

ACCE Conference Report continued...

Most Innovative Material on a Production Part:

Carbon Fiber FMC Roof on 2021 Toyota GR Yaris. Nominated by: Gemini Composites/Mitsubishi Chemical Advanced Materials (MCAM)

Most Innovative Material on a Prototype Part:

Azdel's XL4 Core for Trunk & interior Applications. Nominated by: Hanwha Azdel

People's Choice Award:

Multi-Material Leaf Spring on 2021 Ford F-150. Nominated by: Rassini & Hexion

Other Nominations:

Thermoplastic Composite KyronMax S-4330 Material Roof Receivers on 2021 Jeep Wrangler and Jeep Gladiator. Nominated by: Mitsubishi Chemical Advanced Materials (MCAM)

Mustang I4 Blue Cam Cover with a Low Cost and Reclaimed/Recycled Carbon Fiber. Nominated by: University of Toronto & Ford Motor Co.

PlastiVan®:

Once again, ACCE hosted the PlastiVan® program – this year including 14 students from Ecotec, in Detroit, Mich. The PlastiVan program provides sound science and educational programs, including fun experiments with plastics, which spark scientific curiosity in students while increasing their knowledge of the contribution plastics make to modern life and encouraging them to seek careers in engineering. The Ecotek program is focused on providing academically gifted students in middle school and high school with opportunities to participate in international science research projects. The projects are very challenging and prepare the students for college-level opportunities. After the PlastiVan class onsite at ACCE, the students

continued on page 21...

This Issue:

toured the ACCE exhibits and student posters and enjoyed learning more about automotive composites. In addition, academic leaders from the University of Waterloo, Baylor University, Old Dominion University and University of Tennessee-Knoxville met with the students and advised on the benefits of composites in industry and advanced educational opportunities in the field. Industry professionals from the The Materials Group, INEOS Composites, JM Polymers and Intuit Group met with the students for a round table discussion on careers in the industry. Ecotek students and faculty, PlastiVan program leaders, and ACCE leadership and sponsors all enjoyed the experience.

ACCE Sponsors:

The 2021 SPE Automotive Composites Conference & Expo (ACCE) was made possible by the support of Sponsors including:

Premier Plus Sponsors:

Hexion, INEOS Composites, Mitsubishi Chemical, and Molding Proiducts.

Premier Sponsors:

AOC, Ashland, BASF, BYK, ENGEL, Forward Engineering, Hexagon/MSC Software/eXstream Engineering.

Associate Sponsors:

A & P Tecnology, Aligned Vision, Baylor University PROTOLAB and MTACC, COATS, Composites One, Modkex3D, Dieffenbacher, Fagor Arrasate, Fraunhofer at Western University, Highland Plastics, IACMI, IDI Composites International, Johns Mancville, Michelman, Macrodyne, Re:Build Manufacturing, Sabic, Schmidt & Heinzmann, Zoltek.

Table Top Sponsors:

3A Composites Core Materials, JM POlymenrs RCO Engineering.

Reception Sponsor:

Hexion & Rassini.

Lunch Sponsors:

SAMPE and Lotte Chemical.

Breakfast Sponsor:

Magna. Coffee Break Sponsors: Highland Plastics & Michelman.

Advertising Sponsor:

DSC Consumables.

Media / Association Sponsors:

ACMA, Automotive Engineering, Additive Manufacturing, Autonomous Vehicle Engineering, Composites World, Plastics Business, Plastics Decorating, SPE Plastics Engineering, Plastics News, Plastics Technology Rubber Fibres Plastics International, SAE, SAMPE, Truck & Off-Highway Engineering, Urethanes Technology and WARDSAUTO.COM.

Since 2001, The Automotive and Composites Divisions of the Society of Plastics Engineers (SPE®) have jointly produced the ACCE to educate the industry about the benefits of composites in automotive, light and heavy-duty truck, off-highway vehicles, and other ground transportation applications. The next ACCE event is scheduled for Sept. 7 – 9, 2022 at the same venue as the 2021 event - the Suburban Collection Showplace Diamond Banquet and Conference Center in Novi, Michigan. An "Early Bird Discount" is available to sponsors and exhibitors who commit to supporting the ACCE 2022 event in 2021 and process payment by January 31, 2022.

ACCE 2021 Attendees who took photos at the event are encouraged to send them to teri@intuitgroup.com for posting to the ACCE website.

For more information on the SPE ACCE see https://speautomotive.com/acce-conference/

For more information on the Society of Plastics Engineers, see https://4spe.org/

This Issue:

Award Report

Part of the mandate of the Society of Plastics Engineers – Composites Division is to recognize excellence in composite materials development and proliferation. Several awards have been organized for this purpose to honor and recognize such individuals, both on academic and industrial levels. Every year the Composites Division issues these awards are based on rigorous competitions through solicitation of nominees and applicants. The awards are a) Harold Giles Award, b) Jackie Rehkpof Scholarship, c) Travel Award, and d) Educator of the Year Award.

Other non-financial awards that are open to nominations as of January 1st are a) Honored Service Member / SPE Fellow and b) Composite Division Person of the Year Award. These two awards aim to recognize distinguished contributions from dedicated members of the society.

Harold Giles Scholarships

This award was created in honor of the late Harold Giles who was taken from this world too soon. Harold was one of the best Composite Division Awards Chairs that many of us worked with during his days at Azdel and at UNC. He would have been thrilled to know that we are honoring his name in awarding worthy students. This award is run through SPE International in their Foundation Program series. The Composites Division will select the winners from the pool of applicants in two categories, Graduate and Undergraduate students. The award is dispensed through SPE International to the winners.

The scoring criterion is based on twenty points for the category of scholastic achievements, community service, and other honors, up to ten points based on the strength of the recommendation letters, ten points for previous employment history particularly if this involved composite activity, up to five points for filling out the application form correctly and using good English, five points for providing their transcript and for getting good grades, and a final five points for the reason they applied for the scholarship.

Award Requirements:

- Two awards presented to one undergraduate and one graduate student, who will maintain the academic status for at least one semester after award announcement.
- An essay documenting experience in the composites industry is required (courses taken, research conducted, or jobs held)
- Have not received the award in previous years.
- Winners are typically students who not only maintained a good grade point average but also served their community, had some experience in the composite area, and are backed by solid reference letters from former professors and employers

The award can be up to $3500 per student depending on funding availability.

Key Dates:

Issue call for nominations	February 1st
Close call for nominations	April 31st
Complete award adjudication	June 30th
Notify recipients by	July 30th
Present awards	SPE ACCE

Dr. Jackie Rehkopf Memorial Scholarships

This award is in honor of the late Jackie Rehkopf who was a recognized engineer who published books and was actively involved in the composites industry. The Automotive and Composites Divisions co-sponsor these awards and therefore co-coordinate. This award is presented annually at the SPE ACCE conference each fall and is a premiere award for exemplary performance.

continued on page 23...

This Issue:

Awards Report continued...

Award Requirements

- A single full time grad student or two undergrad students if no grad students qualify
- Preference will be given to female students, but the best candidates will be selected
- Focus should be on research activities targeted to ground transportation composite technology
- Students must be in good academic standing and pursuing a degree in Polymer Science, Composites, Plastics, or a related Engineering discipline
- A 2-page essay is required showing planned work and how it will benefit composites in an automotive or other ground transportation application
- A letter of recommendation from the student's advisor or mentor is also required
- Scholarship recipients are required to present work at an SPE technical conference and/or have it published in an SPE technical journal

The award can be up to $5000 if one student is selected or up to $2500 per student if two are selected, depending on funding availability.

Key Dates

Issue call for nominations	January 1st
Close call for nominations	April 31st
Complete award adjudication	June 30th
Notify recipients by	July 30th
Present awards	SPE ACCE

Travel Award:

This is a two-year award where the applicant fills out an abstract form the first year and returns the second year to present a paper/poster to discuss how the topic has progressed. This reward is presented at ANTEC during the business meeting. Typically, scoring has been based on English, the novelty of the concept, and the strength of the research plan. This is a $2000 award, dispensed in two instalment payments over 2 years. This award is sponsored by industry partners every year. If any company like to sponsor this award, please reach out to the Awards Chair Dr. Hicham Ghossein (hghossein@endeavorcomposites.com).

Award Requirements

- A two-part award presented annually to an undergraduate or graduate student.
- At the time of application, master's students must be in the first year of their program and doctoral students must be in the first two years of their program
- The winner is selected based on a 250-word abstract describing their composites research
- In the first year, the recipient receives a $1000 (USD) scholarship award and a plaque, presented at ANTEC
- To be eligible for the second $1000 installment, the research described in the winning abstract must be presented in a paper at ANTEC the following year

Key Dates

Issue call for nominations	December 1st
Close call for nominations	February 28th
Complete award adjudication	March 14th
Notify recipients by	March 31st
Present awards	ANTEC

Educator of the Year Award:

The Educator of the Year Awards is an industry sponsored award. A certificate/plaque combination will be presented at ANTEC during the business meeting. The present score sheet provides scoring of up to ten points for English at 1X, ten points for recommendation letters at 2X strength, and student support examples at 3X strength.

continued on page 24...

This Issue:

Awards Report continued...

This prestigious recognition is aimed to honor an Educator who have influenced his students to excel in the composite field and grow their composites careers.

Award Requirements

- Someone in the educational field (high school, university, or college-level)
- Has made a significant contribution to the training of students in the composites area. E.G.:
    - o the creation of new educational programs
    - o the development of new pedagogical tools
    - o motivating students to enter the composites sector
- Selection will be based on contributions made during the previous year.
- Must submit a nomination form and two letters of support

The award is $2500, covered by an industry sponsor. If any company like to sponsor this award, please reach out to the Awards Chair Dr. Hicham Ghossein (hghossein@endeavor-composites.com).

Key Dates

Issue call for nominations	December 1st
Close call for nominations	February 28th
Complete award adjudication	March 14th
Notify recipients by	March 31st
Present awards	ANTEC

This Issue:

See page 20 for more details

Award Winning Paper

Physics-Based Simulation Workflow For Stamp Forming Of Thermoplastic Parts

Rebecca A. Cutting, Justin Hicks, Anthony Favaloro, Eduardo Barocio, Garam Kim, Johnathan E. Goodsell, R. Byron Pipes

Composites Manufacturing and Simulation Center, Purdue University, West Lafayette, IN 47906

Abstract

Stamp forming of thermoplastic composites provides an opportunity for the automotive industry to manufacture light-weight components with superior mechanical properties while achieving a reduced cycle time. Prior to stamping, continuous fiber preforms, called blanks, are consolidated on a press. The forming process entails heating the blanks to a processing temperature, quickly shuttling the blanks to the press, and forming the part with a heated, two-sided mold. The forming pressure is held on the part until it cools to a solid state, and then it is ejected from the tooling and continues to cool to ambient temperature. This paper presents a physics-based simulation workflow for the forming, heat transfer, and subsequent part deformation of a thick, double-curvature part made with CF-PEKK. The forming process and any subsequent wrinkling and fiber reorientation is captured with the software AniForm. The updated fiber angles from the forming simulation are used as inputs for a sequentially coupled thermo-mechanical analysis in Abaqus, which predicts the temperature and crystallinity history of the part during forming and cooling. These results are fed into a mechanical analysis which captures the build-up of residual stresses and subsequent relaxation and deformation of the part as it cools outside of the tool. Finally, the predicted deformation is compared to the experimentally measured warpage of a part made with this manufacturing cycle.

Introduction & Background

Thermoplastic composites offer the promise of high-rate manufacturing to meet the anticipated volume of composite materials in the future. Stamp forming of thermoplastic composites is a high-rate manufacturing process amenable to the automotive industry. Like stamp forming of metals, thermoplastic stamp forming uses pressure and heat to form the composite laminate; hence, the existing stamping infrastructure in the automotive supply chain could be updated to stamp forming composites. In addition to high rate, stamp forming can produce parts with superior mechanical performance, owing to the continuous-fiber architecture of the preform laminate. However, as with metal stamp forming, tooling is expensive and producing a quality part is often an expensive experimental trial-and-error process.

Modeling and simulation offer to reduce the experimental burden and allow science-based design of thermoplastic stamp formed parts, process, and tooling. However, the physics involved in the stamp forming process are numerous, complex, and to-date, no single workflow exists to allow a design engineer to numerically simulate all the phenomenon relevant to the part, manufacturing process, and tool design. Researchers at the Composites Manufacturing and Simulation Center at Purdue University have combined the existing solutions for thermoplastic stamp forming into a prototype workflow with the aim of enabling part, process, and tooling design from a single solution. Physics include: anisotropic

continued on page 26...

This Issue:

thermo-viscoelasticity, polymer crystallization, thermal and crystallization shrinkage, anisotropic heat transfer, part-tool friction, and ply-ply interaction [1–5]. The workflow connects the simulation code AniForm, to simulate the forming process, including tool-part interaction and ply-ply interaction, at forming temperature; and Abaqus, to simulate anisotropic heat transfer, kinetics of polymer crystallization, anisotropic thermo-viscoelasticity, and thermal and crystallization shrinkage of the composite material [1]–[6]. This workflow enables simulation of the heating and cooling processes, and the subsequent development of crystallinity, shrinkage, residual stresses, and post-forming warpage. The workflow has been exercised to predict the effects of processing, including gripping conditions and thermal history, on part quality, as measured by wrinkle formation and warpage of the formed part.

Materials and Manufacturing Process

The material used for all analyses and manufacturing in this study is AS4-PEKK carbon composite prepreg. Forming of thermoplastic composites is a multi-stage process. The first stage involves cutting each ply to shape and laying them up in a ply-stack. The ply-stack is then heated past melt-point and consolidated under pressure in a heated press, creating what is known as a blank. The blank cools slowly to room temperature and is removed from the consolidation tool. The blank is then transferred to the forming equipment. The blank is held around its edges in a picture frame-like apparatus using a range of possible devices, including mechanical fingers, grips and hooks. These devices assist with holding the blank in the correct location during the heating and forming stages of the manufacturing process. The blank is shuttled into an IR oven where it is heated to a temperature higher than the melt-point of the thermoplastic matrix. When the entire laminate is above the melt temperature, the blank is shuttled at high speed into the press which holds the forming tools. The forming tools and press are heated to control the cooling rate and temperature plateau of the formed part once the tools move into contact with the blank during the final step of the forming process. Double-sided tools form the blank into the part geometry under pressures typically in the range of 500 psi. The part has some excess material remaining around the edges at the conclusion of this step and is, therefore, typically subjected to a machining step to remove the excess and trim the part to its final geometry.

continued on page 27...

Award Winning Paper continued...

Simulation Framework

The simulation sequence performed in this work begins with the part design. From the designed part geometry and ply table, the outer and inner surfaces are extracted to provide surfaces for tool design, and ply flattening analysis is performed in CATIA to determine the flat ply contours to be used in the forming simulation as well as physically to cut plies to the required shape on a Gerber table. First, a forming simulation is performed in AniForm using the tooling surfaces, flattened ply shapes, and ideal ply fiber angles. The result of the forming simulation is the deformed state of each ply in the part including any reorientation of fiber angles. Next, an ideal 3D mesh of the as-designed part is generated for use in Abaqus. However, the updated fiber angles from the forming simulation are mapped in an in-ply nearest neighbor mapping so that the Abaqus simulation represents the as-manufactured fiber angles. Finally, a sequentially coupled heat transfer then warpage simulation is performed to determine the contribution of thermal and crystallization shrinkage to the as-manufactured part shape.

Forming simulations are performed using the large deformation finite element analysis software AniForm [6–8]. AniForm models the in-plane and bending behavior of each ply in the ply stack as well as the ply-ply interactions and ply-tool interactions. The requisite material information for the simulation was previously characterized by the project sponsor and is proprietary. The flattened ply shapes are 2D geometries, while the tooling surfaces are 3D geometries and lie in the part's design coordinate system. Initial ply and tool alignment are performed using the seed point for ply flattening as a mutual index.

Heat transfer and warpage simulations are performed in Abaqus in a sequentially coupled manner similar to the Purdue CMSC's Additive3D simulation workflow [9–12] First, the local fiber orientation is obtained via mapping from the AniForm simulation. Next, a heat transfer simulation is performed which accounts for the applied thermal boundary condition history (initial radiant heating, radiant heat losses, convective heat losses, conduction heat losses into the tooling). The mate-

continued on page 28...

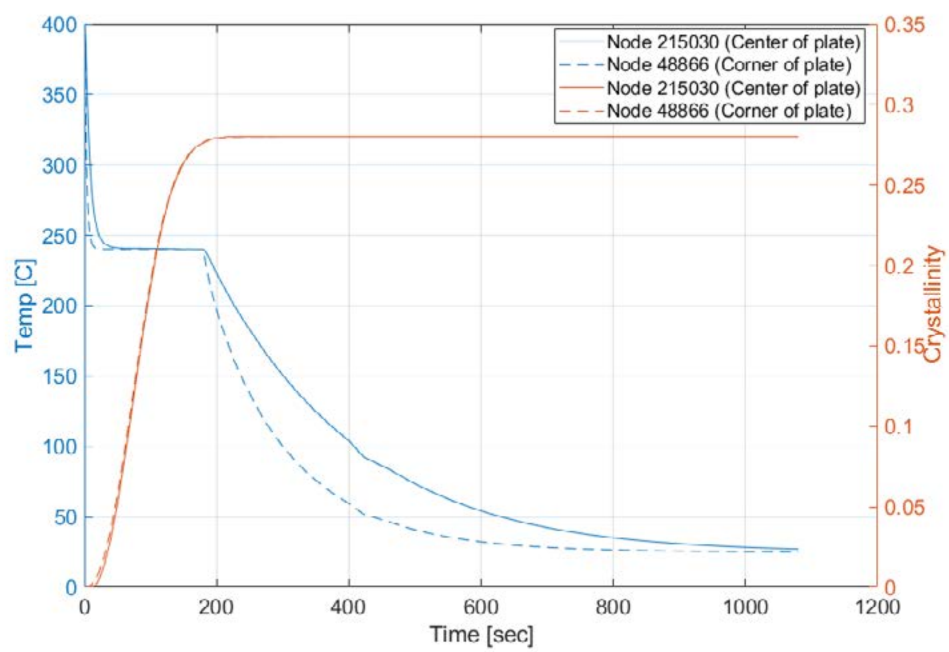


Figure 1: Temperature and crystallinity histories of the center and a corner on the part

This Issue:

rial model and properties are implemented in Abaqus user subroutines and are temperature dependent specific heat (UMATHT), temperature dependent orthotropic conductivity (UMATHT), crystallization kinetics (UMATHT in heat transfer, UEXPAN in warpage), thermal and crystallization related expansion strains (UEXPAN), and viscoelasticity (UMAT). In each time increment, the temperature history is used to calculate the crystallization history which in turn affects the viscoelastic behavior and expansion strains. While most of the remaining investigation is related to the deformation of the part, the temperature and crystallinity histories play a major role in determining the deformation. Therefore, representative temperature and crystallinity histories are shown for completeness in Figure 1 for a node located in the center of the part and ply stack as well as a node at the corner of the part in the center of the ply stack. The corner of the part cooled faster than the center of the part, but the crystallinity developed at the same rate for each.

Effect of Processing Conditions

The effects of processing conditions including pre-loading of the blank via springs and the temperature of the forming tool on the wrinkles and residual deformation developed in the part after the forming process were investigated using the forming simulation workflow.

Effect of Pre-Loading on Preform

A series of models was developed in AniForm to understand the effect of pre-loading via springs on the forming and subsequent wrinkling of the part. Figure 2 shows the spring configurations tested. The total number of springs varied from 6-12, and up to 3 vertical and 3 horizontal springs were placed per edge. The models contained the same material properties, analysis mesh, and processing conditions. The only difference between models was the number and location of the springs.

continued on page 29...

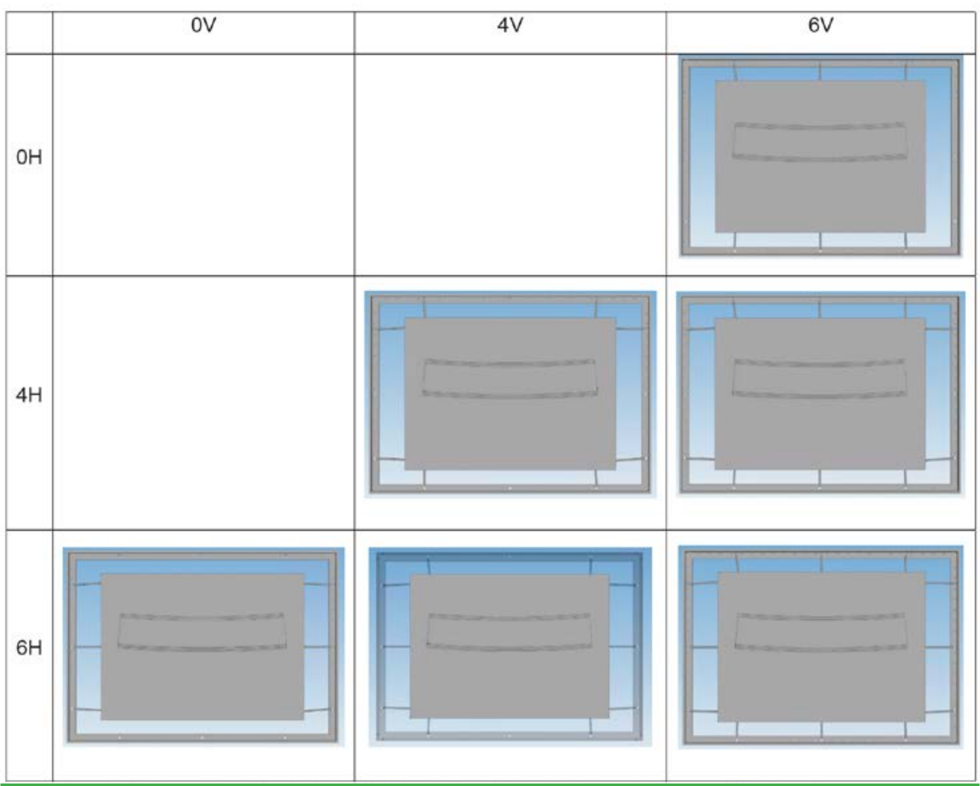


Figure 2: Spring configurations tested in AniForm to look at the effect of pre-loading on wrinkle formation

This Issue:

Award Winning Paper continued...

A change in sign of shear strain can be caused in the part when an out-of-plane wrinkle is flattened into shape conformity. Therefore, identifying locations where shear strain crosses 0 indicates a wrinkle location. Figure 3 shows the shear strain maps for each of the spring configurations, and the legend for the shear strain ranged from -0.1 to 0.1 in order to capture any strain reversals. Every simulation produced wrinkles around the inner ply drop-offs (where the smaller plies are outlined on the interior of the preform). However, the case with 6 horizontal springs and 6 vertical springs (6H-6V) produced the smallest amount of wrinkling in the top center portion of the part of the formed part.

The stamped preform has excess material that is trimmed before the part is ready for use. Wrinkling on the excess of the part is less concerning than wrinkling and deformation in the final trimmed part. Figure 4 shows the shape of the stamped AniForm model (black) compared to the as-designed final geometry (blue). The AniForm results mesh was trimmed to match the as-designed final geometry shape, so all deformation comparisons are between parts of the same size.

continued on page 30...

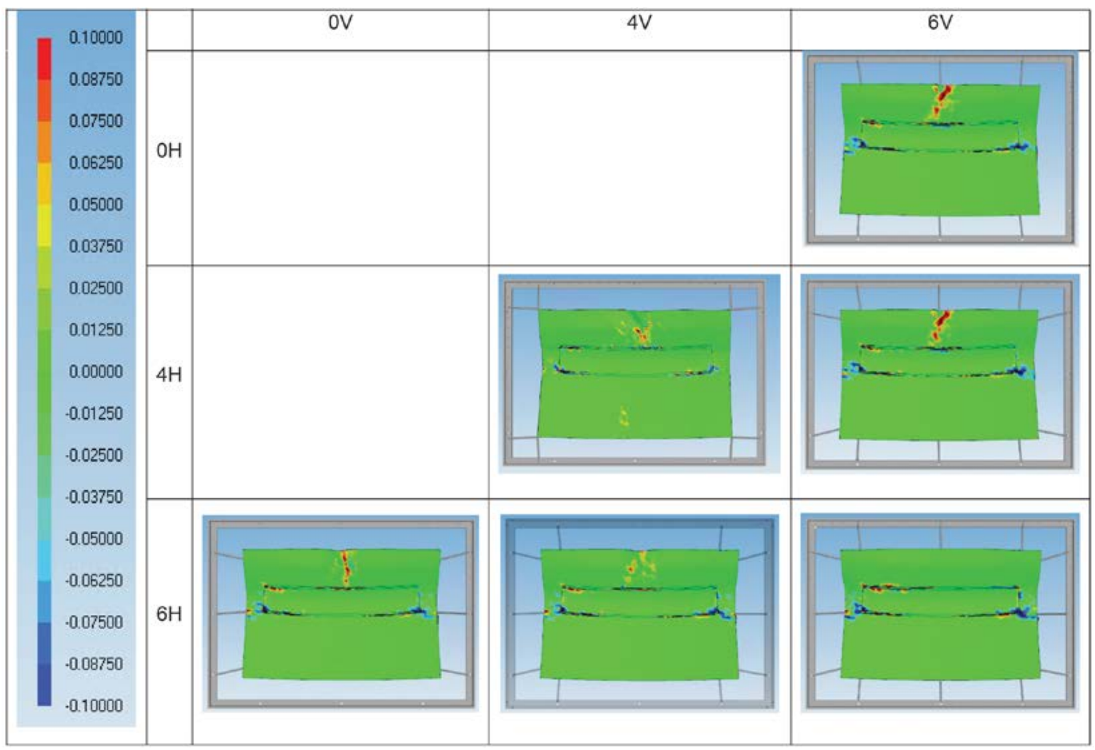


Figure 3: Shear strain reversals on the formed part representing likely locations of wrinkles

This Issue:

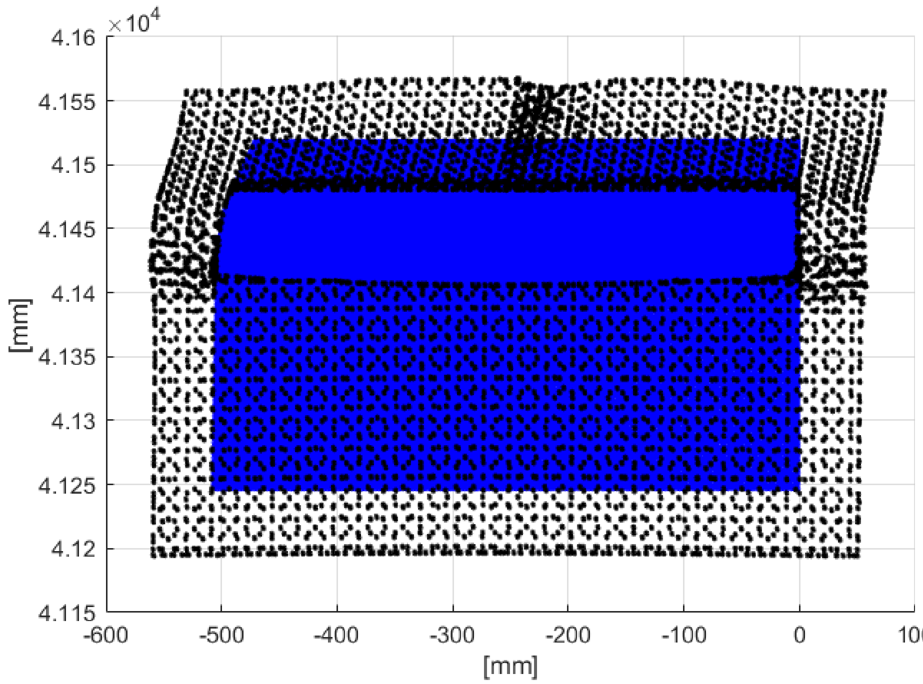


Figure 4: Shape of the stamped preform (black) versus the final trimmed part (blue)

Once the AniForm results mesh was trimmed to represent the final part, the forming simulation results were compared to the as-designed geometry. The nearest neighbor node in the AniForm model was located for every node in the as-designed geometry mesh. The L_1, L_2, and $L\infty$ norms were calculated for each of the spring configurations, with the norms are defined as:

$$L_1 = \sum|distance| \quad [1]$$

$$L_2 = \sqrt{\sum distance^2} \quad [2]$$

$$L_\infty = \max\,(distance) \quad [3]$$

Where the variable $distance$ is an array of the distances between nodes on the AniForm results mesh and the as-designed geometry mesh. These results were normalized and are shown in Table 1- Table 3. The spring configuration with 4 horizontal springs and 6 vertical springs (4H-6V) consistently had the lowest norm. This spring configuration did show more wrinkling in the top portion of the formed shape (see Figure 3) than the 6H-6V spring case. However, these results compare the final trimmed shape to the as-designed geometry, so some of the wrinkling seen earlier would be removed. These results indicated the best spring configuration was 4H-6V, therefore, this setup was used in the manufacturing process.

Table 1: L_1 norm for total distance between forming simulation results and as-designed geometry

	L_1	Vertical Springs 0V	4V	6V
Horizontal Springs	0H			1.040
	4H		1.201	1.000
	6H	1.039	1.039	1.045

Table 2: L_2 norm for total distance between forming simulation results and as-designed geometry

	L_2	Vertical Springs 0V	4V	6V
Horizontal Springs	0H			1.036
	4H		1.168	1.000
	6H	1.034	1.035	1.040

Table 3: $L\infty$ norm for total distance between forming simulation results and as-designed geometry

	L_∞	Vertical Springs 0V	4V	6V
Horizontal Springs	0H			1.037
	4H		1.040	1.000
	6H	1.041	1.041	1.026

This Issue:

Award Winning Paper continued...

Effect of Tool Temperature on Warpage

The effect of tool temperature on warpage was also investigated using the sequentially coupled thermo-mechanical analysis performed in Abaqus with the local fiber orientations from the forming simulation mapped over from Aniform. The blank was initialized at the melt temperature of the polymeric matrix (400 °C) and in the amorphous state (zero crystallinity). Subsequently, a temperature boundary condition was used to represent the temperature of the forming tool whereas convective and radiative heat transfer mechanisms were applied on the exposed side surfaces of the blank. Similarly, a kinematic boundary condition was applied on one side of the part to represent the geometric constraint imposed by the tool upon forming. Following the forming process, the part was held for five minutes inside the tool and at the tool temperature before it was released. Upon release, convective and radiative heat losses controlled the cooling history of the part from the tool temperature to the ambient temperature. A few nodes were constrained at the center of the part to prevent rigid body motion as internal stresses and deformation developed while cooling down.

The effect of tool temperature on warpage was investigated for five different temperatures equally spaced in a range from 150 °C to 250 °C wherein the lower temperature bound is around the glass transition temperature of the polymeric matrix. Figure 5 shows the magnitude of displacement (mm) from warpage

continued on page 32...

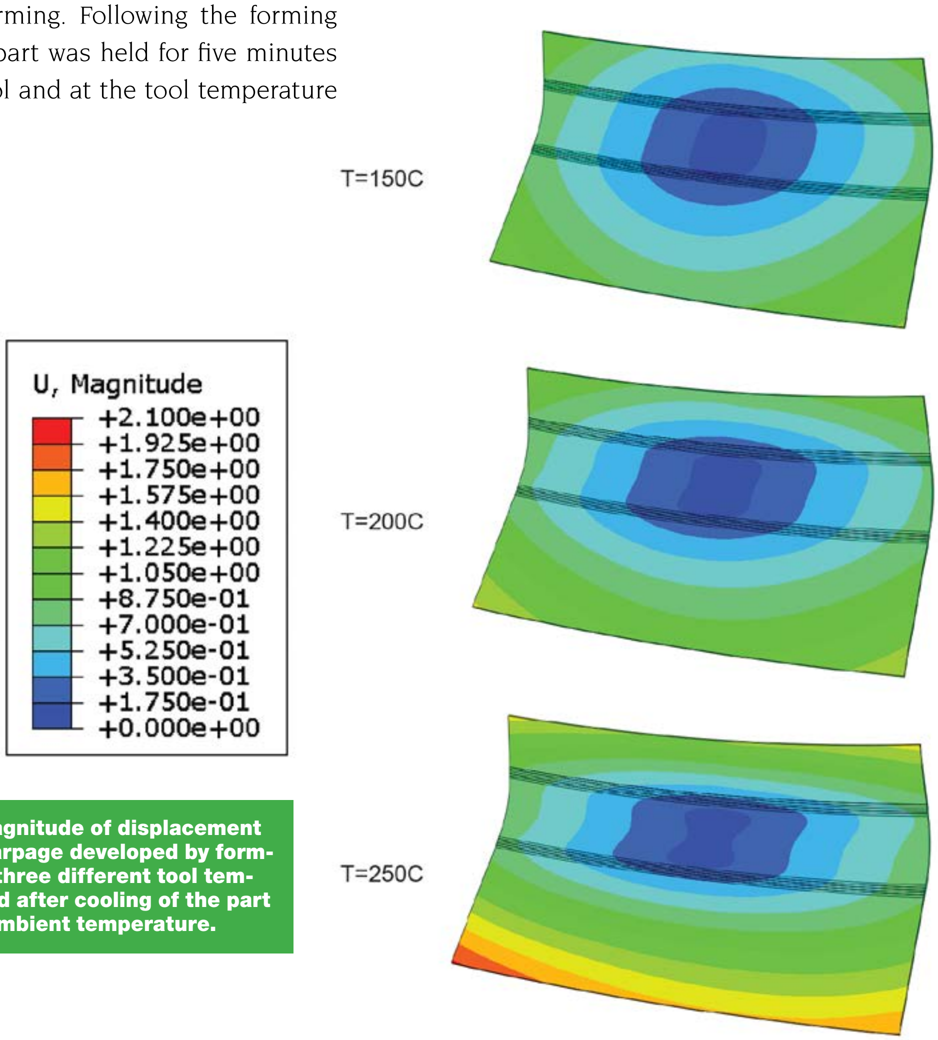


Figure 5: Magnitude of displacement (mm) from warpage developed by forming part at three different tool temperatures and after cooling of the part to the ambient temperature.

This Issue:

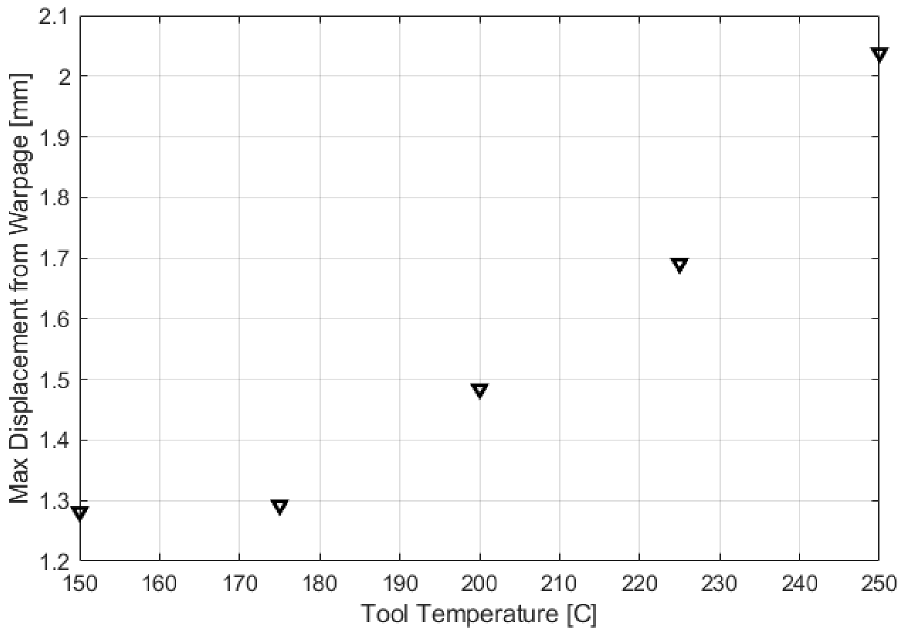


Figure 6: Maximum displacement from warpage developed for different tool temperatures

developed by forming the part at three different tool temperatures, 150,200 and 250 °C, and cooling the part to ambient temperature afterwards. The displacement field in Figure 5 shows that the part springs-in in both directions, yet dominantly in the direction with the smallest radius of curvature.

Figure 6 shows the maximum displacement (mm) from warpage that resulted from the five tool temperatures investigated. The results clearly show that the larger the temperature difference between the tool and the ambient air, the larger the maximum displacement or spring-in. This behavior agrees with well-established equations for predicting spring-in behavior in laminated composites such as the Radford's equation [13] wherein the angle change is proportional to the temperature difference and the difference in in-plane to through-thickness coefficient of thermal expansion.

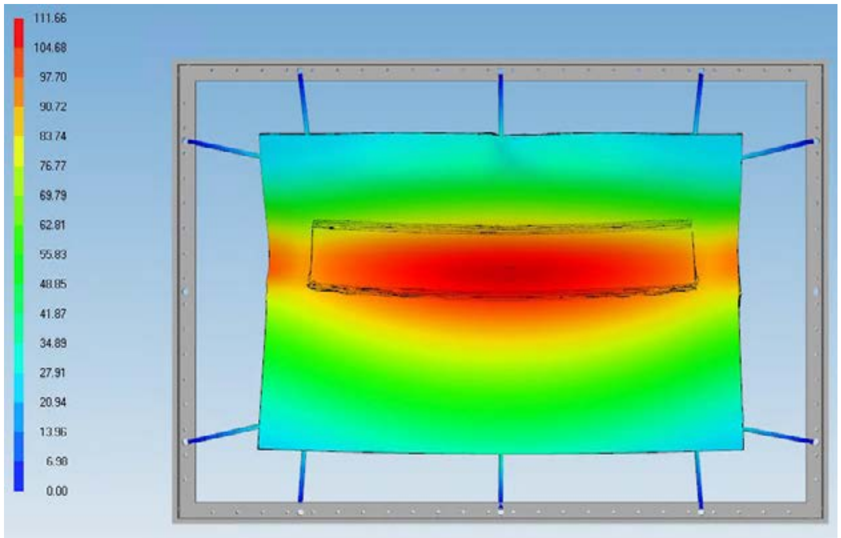
Simulation and Manufacturing Outputs

The output of the simulation workflow is used to predict the shape of the as-manufactured part. The sequentially coupled simulated forming process provides a prediction of the final shape of the part by coupling the effects of mechanical forming (simulated in Aniform) and thermal effects during manufacturing (simulated in Abaqus).

An example output (from Aniform) of the simulated displacements in the formed part, including mechanisms such as ply movement, ply-tool interface friction, and ply-ply interactions, is displayed in Figure 7a. These displacements are then added to the deformation outputs from the Abaqus simulation. The simulated output (from Abaqus) of the deformed state of the part are due to the effects of heat transfer on the shrinkage and relaxation of the semi-crystalline polymer and is displayed in Figure 7b. The goal is to compare the combined displacement and warpage results to the as-manufactured shape produced experimentally. An example part that has been manufactured using the thermoplastic composites forming process outlined previously, is displayed in Figure 7c.

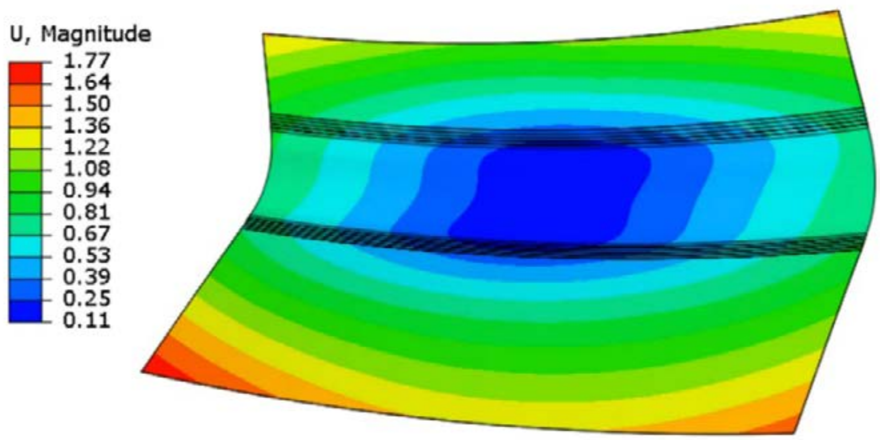
continued on page 33...

This Issue:



(a) Aniform Displacement Results [mm]

(b) Abaqus Warpage Results [mm]



(c) Experimental Results

Figure 7 (a) Simulated Aniform displacement results due to the forming process, (b) Simulated Abaqus warpage results adding the effects of heat-transfer, and (c) An as-manufactured part produced at the Purdue CMSC, created using the thermoplastic composites forming process.

This Issue:

Conclusions

This work presented a simulation workflow for stamp forming of thermoplastic composites using the software AniForm and Abaqus. The forming of a blank at temperature is simulated in AniForm, and the updated geometry (including wrinkles) and fiber orientations are input into a sequentially coupled heat-transfer and warpage analysis. Initial results show that processing conditions like pre-loading on the blank and tool temperature affect the final part shape. The simulation process introduced in this work has the potential to predict manufacturing issues and inform the part, processing cycle, and tooling design. This framework will be used to guide future experimental investigations seeking to improve part quality.

Future work will be completed to validate the simulation workflow. This will involve manufacturing a part under the same conditions as the simulation and characterizing the deformed shape using 3D metrology processes. Additionally, parts will be created with embedded thermocouples in them to collect the time-temperature history at different locations within the laminate. This data will then be used to validate the predicted time-temperature histories and crystallinity development at the same locations in the simulated part throughout the simulation workflow.

Acknowledgements

The authors wish to acknowledge the support of the Boeing Company for our research in the Hybrid Forming of Continuous Fiber Thermoplastic Composites under Purdue University Master Research Agreement No. 2017-036.

Bibliography

1. Velisaris CN, Seferis JC. Crystallization kinetics of polyetheretherketone (peek) matrices. Polymer Engineering & Science 1986;26:1574–81. https://doi.org/10.1002/pen.760262208.
2. Sunderland P, Yu W, MÃ¥nson J-A. A thermoviscoelastic analysis of process-induced internal stresses in thermoplastic matrix composites. Polymer Composites 2001;22:579–92. https://doi.org/10.1002/pc.10561.
3. Chapman TJ, Gillespie JW, Pipes RB, Manson JAE, Seferis JC. Prediction of Process-Induced Residual Stresses in Thermoplastic Composites. Journal of Composite Materials 1990;24:616–43. https://doi.org/10.1177/002199839002400603.
4. Ozisik MN. Heat conduction. John Wiley & Sons; 1993.
5. Greco A, Maffezzoli A. Statistical and kinetic approaches for linear low-density polyethylene melting modeling. Journal of Applied Polymer Science 2003;89:289–95. https://doi.org/10.1002/app.12079.
6. ten Thije R. Finite element simulations of laminated composite forming processes. 2007.
7. ten Thije RHW, Akkerman R. A multi-layer triangular membrane finite element for the forming simulation of laminated composites. Composites Part A: Applied Science and Manufacturing 2009;40:739–53. https://doi.org/10.1016/j.compositesa.2009.03.004.
8. ten Thije RHW, Akkerman R, Huétink J. Large deformation simulation of anisotropic material using an updated Lagrangian finite element method. Computer Methods in Applied Mechanics and Engineering 2007;196:3141–50. https://doi.org/10.1016/j.cma.2007.02.010.
9. Favaloro A, Brenken B, Barocio E, Pipes RB. Simulation of Polymeric Composites Additive Manufacturing using Abaqus. Science in the Age of Experience by Dassault Systemes, 2017.
10. Brenken B, Barocio E, Favaloro A, Kunc V, Pipes RB. Development and validation of extrusion deposition additive manufacturing process simulations. Additive Manufacturing 2019;25:218–26. https://doi.org/https://doi.org/10.1016/j.addma.2018.10.041. 11. Barocio Vaca E. Fusion Bonding of Fiber Reinforced Semi-Crystalline Polymers in Extrusion Deposition Additive Manufacturing. 2018.
12. Barocio E, Brenken B, Favaloro A, Bogdanor M, Pipes RB. Extrusion Deposition Additive Manufacturing with Fiber-Reinforced Thermoplastic Polymers. In: Friedrich K, Walter R, editors. Structure and Properties of Additive Manufactured Polymer Components. 1st ed., Woodhead Publishing; 2020. 450.
13. Radford DW, Diefendorf RJ. Shape Instabilities in Composites Resulting from Laminate Anisotropy. Journal of Reinforced Plastics and Composites 1993;12:58–75. https://doi.org/10.1177/073168449301200104.

This Issue:

Call For Papers

AUTOMOTIVE COMPOSITES CONFERENCE & EXHIBITION

Novi, MI • September 7-9, 2022

Presented by SPE Automotive and Composites Divisions

WORLD'S LEADING AUTOMOTIVE COMPOSITES FORUM

OR IMMEDIATE RELEASE: 13 JANUARY 2022
Media Contact: Teri Chouinard,
SPE Auto. Div. Comm. Chair, 248.701.8003,
teri@intuitgroup.com

SPE® ACCE (Automotive Composites Conference & Expo) Announces Call For Papers, Sponsors & Exhibitors For 2022 Event:

"Composites: The Key To EV"

The SPE Automotive Composites Conference & Expo (ACCE) team is announcing its Call for Papers, Sponsors & Exhibitors for their 22nd annual event September 7 - 9, 2022 at the Suburban Collection Showplace in Novi, Michigan. "Composites: The Key to EV" is the theme for the 2022 event. "Composites are playing a key role in the development of electric vehicles, said Dr. Leonardo Simon, professor, Chemical Engineering at University of Waterloo and returning ACCE 2022 -chair. "Lightweight composites are ideal materials for improving vehicle performance, reducing mass, extending range and compensating for battery weight," continued Simon. "Polymer composites are also enabling lower emission vehicles, reducing carbon footprint and saving energy to benefit the environment now and in the future," added Simon. "Thermoset and thermoplastic composites are the key to EV, Mobility & Sustainability."

The ACCE features technical sessions, panel discussions, keynotes, and exhibits highlighting advances in materials, processes, and equipment for both thermoset and thermoplastic composites in a wide variety of transportation applications. Networking breakfasts, lunches, and receptions enhance the value of the event that typically attracts over 800 attendees from across the globe. The Automotive and Composites Divisions of the Society of Plastics Engineers (SPE®) jointly produce the ACCE to educate the industry about the benefits of composites in transportation applications.

The technical program will be co-chaired by returning 2018, 2019, 2020 and 2021 co-chair Dr. David Jack, professor, Mechanical Engineering at Baylor University and returning 2020 and 2021 co-chair Dr. Alex Kravchenko, assistant professor, Composites Modeling and Manufacturing Group, Department of Mechanical and Aerospace Engineering at Old Dominion University, and new co-chair Dr. John W. (Jack) Gillespie Jr., director, Center for Composite Materials (CCM) at University of Delaware. "This year's program will launch a new session/track of papers on Composites in Electric Vehicles and include presentations on how composites are enabling advances in mobility," said Jack. "The technical program will also have an expanded track of papers on Sustainable Composites, said Kravchenko.

continued on page 36...

This Issue:

Call For Papers continued...

The 2022 ACCE technical program will include 80 – 100 technical presentations on current and future industry advances. In addition to the new category on Composites in Electric Vehicles, the presentations are organized into the following categories: Thermoplastic Composites; Thermoset Composites; Modeling; Additive Manufacturing & 3D Printing; Enabling Technologies; Sustainable Composites; Bonding, Joining & Finishing; Carbon Composites; and Business Trends/Technology Solutions. Paper abstracts are requested as soon as possible and are due by April 15th, 2022. Final papers or non-commercial presentations are due June 17th, 2022. Authors who submit full papers (not presentations) in the proper format will be considered for the conference's Best Paper Awards, which are presented during the event's opening ceremony. A template for papers can be downloaded from the SPE ACCE website online via http://speautomotive.com/acce-forms. Inquiries about submitting papers can be sent to ACCEpapers@speautomotive.com.

A Variety of Sponsorship and Exhibit Options offer companies the opportunity to support the event and promote their products and services to a very targeted and interested audience. Student Poster Competition and Scholarship sponsorships are also available. All sponsorships include passes to the event including access to all keynotes, panel discussions, technical sessions and daily networking opportunities. Sponsorship also includes corporate exposure on SPE ACCE websites, advertising, publicity, social media, signage throughout the event venue and more. Early Bird Sponsors to date for ACCE 2022 include Hexion, Ineos Composites, Molding Products, MSC Software Corporation/Hexagon, BYK USA, Dieffenbacher, Baylor University MTACC & Protolab, Schmidt & Heinzmann and DSC Consumables. Companies interested in supporting the event with sponsorship and showcasing their products and services should contact Teri Chouinard at teri@intuitgroup.com and go to www.speautomotive.com/acce-conference for more information.

The mission of SPE is to promote scientific and engineering knowledge relating to plastics worldwide and to educate industry, academia, and the public about these advances. SPE's Automotive Division is active in educating, promoting, recognizing, and communicating technical accomplishments in all phases of plastics and plastic-based composite developments in the global transportation industry. The SPE Composites Division is dedicated to the growth of composites in multiple industries. Topic areas for both divisions include applications, materials, processing, equipment, tooling, design, and development.
For more information see http://speautomotive.com and https://composites.4spe.org. For more information on the Society of Plastics Engineers, see www.4spe.org. SPE® is a registered trademark of the Society of Plastics Engineers.

spe® COMPOSITES

This Issue: