spe AUTOMOTIVE PLASTICS NEWS

A PUBLICATION OF THE AUTOMOTIVE DIVISION OF THE SOCIETY OF PLASTICS ENGINEERS

SPRING 2020
VOL 49, ISSUE 3

20TH ANNUAL

AUTOMOTIVE COMPOSITES CONFERENCE & EXHIBITION

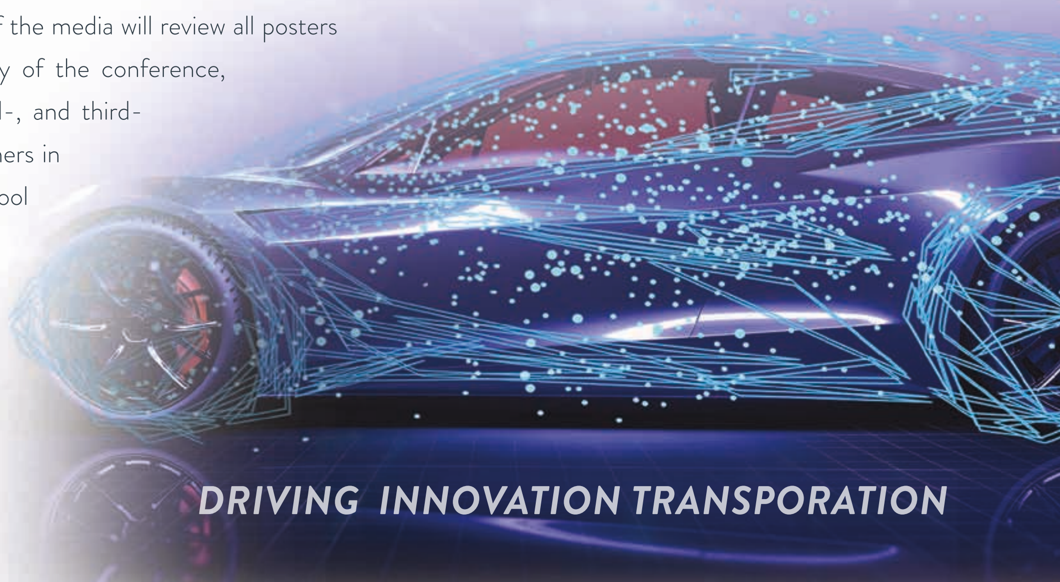
Novi, Michigan • September 9-11, 2020

Presented by SPE Automotive Division and SPE Composites Division

SPE® ACCE 2020 – AUTOMOTIVE COMPOSITES CONFERENCE & EXPO ANNOUNCES CALL FOR ABSTRACTS FOR SPE® ACCE STUDENT POSTER COMPETITION – *ABSTRACTS DUE JULY 1, 2020*

The organizing committee for the SPE® Automotive Composites Conference & Expo (ACCE) invites graduate, undergraduate, community college, and high school students to submit abstracts on innovative composites technologies, for automotive and ground transportation, for its annual student poster scholarship competition. The competition will be held during the ACCE at the Suburban Collection Showplace in Novi, Michigan (in the Detroit suburbs) September 9 - 11, 2020. Judges who are industry experts, SPE board members, and members of the media will review all posters with student authors on the first day of the conference, September 9, 2020. First-, second-, and third-place awards will be presented to winners in graduate, undergraduate and high school categories during a special ceremony after lunch on the event's second day, September 10, 2020.

Continued on page 4



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spe AUTOMOTIVE

MEETING SCHEDULE & SPECIAL EVENTS CALENDAR

SPE Auto. Div. Board Meeting
Skype Only — 5:30 - 7:30 p.m.
April 20, 2020

15th-Annual AutoEPCON
Troy Marriott — Cancelled
Troy, MI USA — April 28, 2020

SPE Auto. Div. Board Meeting
American Chemistry Council - Auto. Ctr. — 5:30 - 7:30 p.m.
Troy, MI USA — June 15, 2020

SPE Auto. Div. Board Meeting
American Chemistry Council - Auto. Ctr. — 5:30 - 7:30 p.m.
Troy, MI USA — August 17, 2020

25th-Annual SPE Automotive Division Golf Outing
Fieldstone Golf Course — All Day
Auburn Hills, MI USA — September 8, 2020

20th-Annual Automotive Composites Conference and Exhibition
Diamond Banquet and Conference Center — All Day
Novi, MI USA — September 9 - 11, 2020

SPE Auto. Div. Board Meeting
American Chemistry Council - Auto. Ctr. — 5:30 - 7:30 p.m.
Troy, MI USA — October 19, 2020

50th-Annual Innovation Awards Gala
Burton Manor — 4:30 - 11:00 p.m.
Livonia, MI USA — November 19, 2020

SPE Auto. Div. Board Meeting
American Chemistry Council - Auto. Ctr. — 5:30 - 7:30 p.m.
Troy, MI USA — December 7, 2020

Automotive Division Board of Directors meetings are open to all SPE members. All events are listed on our website at
http://speautomotive.com
Email Dave Helmer at
auto-div-chair@speautomotive.com
for more information.

CHAIR'S WELCOME

DAVE HELMER, SPE AUTOMOTIVE DIVISION CHAIR

SPE AUTOMOTIVE

Wow – the rapid spread of COVID-19 has quickly influenced the entire world. Since the last newsletter our world has changed to social distancing, telecommuting if possible, and sheltering in place. The North American automotive industry has closed plants following national directives. Pockets of automotive have even begun transforming to produce life saving equipment such as face shields, masks, and ventilators. The majority of materials making those components are plastics in the elastics, filters, clear shields, gears, housing, etc. So although times are tough now – we can proudly say plastics are contributing to the solution.

Looking forward – "this too shall pass" – as I write this the China teams are slowly going back to work. Our industry in North America will be back up and running quickly to meet pent up demand. Hopefully by next newsletter, the North American automotive industry will be dealing with force majeure re-start issues, part shortages, and ramping up to meet customer demands.

On to regular business, first from the automotive team, I want to congratulate Chuck Jarrett on being honored by our Board of Directors at the February board meeting for his outstanding contributions. Chuck has volunteered countless hours primarily in support of educational outreach activities through PlastiVan®, MAIN Event, and Scholarships. Thank you again Chuck for making SPE Automotive a better division through your volunteer work.

Second, the automotive team held the second sponsor appreciation event at Fogo de Chão on Wednesday, January 22nd. We had a chance to meet and greet with our sponsors – they really make SPE Automotive run. Thank you to the sponsors as well as Teri Chouinard who did a great job coordinating the whole event.

Third, our early events for this year have been at the mercy of COVID-19. Originally scheduled for March 24/25 this year, the TPO Shanghai Conference has been delayed until 2021. ANTEC 2020 moved from a live conference planned in San Antonio, Texas to a virtual conference. AutoEpcon 2020 originally scheduled for April 28th in Troy Michigan has been cancelled.

I hope you found this informational and hope by press time we will be rebounding. At any time, if you have ideas on how to make our section better or would like to volunteer, do not hesitate to contact me at auto-div-chair@speautomotive.com. Most importantly, stay safe in these times.

Thank you,

Dave Helmer

Continued from page 1

CALL FOR ABSTRACTS – SPE® ACCE STUDENT POSTER COMPETITION

Students interested in participating in the scholarship competition should contact Dr. Uday Vaidya, ACCE student poster competition chair as well as chief technology officer, Institute for Advanced Composites Manufacturing Innovation (IACMI) and professor and governor's chair – Advanced Composites Manufacturing at University of Tennessee-Knoxville via **ACCEposters@speautomotive.com**.

Abstracts are due by July 1, 2020. Digital copies of posters are due by August 20, 2020 for pre-review by judges. Students will need to bring printed copies of their posters to the conference, which they can attend free of charge. All students in the competition will also receive a partial travel stipend and a shared hotel room provided by SPE, as well as free student membership in SPE.

Large multi-poster panels and push pins for displaying the posters in the Student Poster Display area will be provided. The show also provides excellent networking opportunities for those close to graduating who are starting to look for a job.

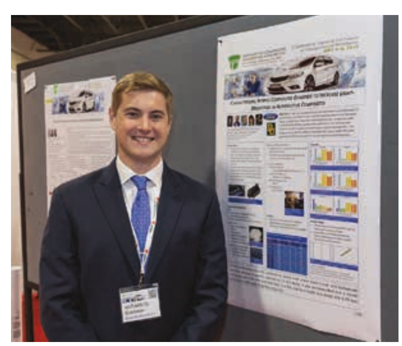
The poster template is online via **http://speautomotive.com/acce-forms**. Poster topics may include subjects such as:

- Automotive Composites
- Composites and lightweight materials for trucks
- Bio-composites
- Nanocomposites
- Glass, carbon, and hybrid fibers
- Thermoset and thermoplastic technologies
- Recycling and green technologies
- Multi-materials
- Joining technologies
- Modeling and analysis of lightweight materials
- CAFÉ standards and mandates
- Cost-effective manufacturing
- Use of advanced materials in innovative applications
- Virtual prototyping and design
- Microstructure, failure and fracture
- Failure envelopes and theories
- Additive manufacturing of composite

Students and their posters are 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;
- Conclusions are supported by information presented;
- Presentation (display aesthetics are pleasing and there is a logical flow between sections);
- Knowledgeable (presenter has a good grasp of the subject);
- Understandability (poster is effective even without student being present to explain it); and
- Overall rank vs. other posters and presenters.

Three of the 2019 poster competition winners are shown below. The first photo on the left shows Wei Wu, PHD, from University of Southern California, accepting her plaque for the First-Place PHD Category–Design, Manufacturing, Simulation and Joining from Alper Kiziltas, ACCE Co-Chair from Ford Motor Company, the 2019 student poster competition sponsor (DuPont also provided student poster competition sponsorship support). The photo in the middle shows student poster competition participants on stage between Alper Kiziltas and Debbie Mielewski from Ford Motor Company. The photo on the right shows Nate Blackman, PhD, from Baylor University, next to his poster, which won Third-Place in the same category.



For more information on the ACCE Student Poster Competition, contact:

- Dr. Uday Vaidya, University of Tennessee-Knoxville, 205.410.2898, **uvaidya@utk.edu**
- Dr. Douglas E. Smith, Baylor University, 254.710.6830, **Douglass_E_Smith@baylor.edu**
- Dr. David Jack, Baylor University, 254.710.3347, **David_Jack@baylor.edu**

Please include in the Subject Line –

2020 SPE ACCE Student Poster Competition

SPE® ACCE ANNOUNCES CALL FOR NOMINATIONS FOR INNOVATIVE PARTS COMPETITION AT 2020 EVENT

The organizing committee for the SPE Automotive Composites Conference & Exhibition (ACCE) today issued a call for nominations for its annual innovative parts competition at the group's 2020 conference, September 9-11 at the Suburban Collection Showplace in Novi, Michigan. Any registered conference participant (speaker, sponsor/exhibitor, or attendee) may nominate original equipment or aftermarket composite parts on passenger vehicles, light trucks and heavy trucks from any geography. Prototype parts are also eligible. Companies, organizations and universities are all encouraged to participate and get recognized for their innovative production parts or prototypes. The vehicle producer must give permission and the part must be brought to the SPE ACCE for a formal review by judges. A total of five prizes will be awarded including four for the most innovative Production Part and Prototype Part in Materials Innovation and Process Innovation categories (selected by judges who are industry experts and members of the SPE ACCE planning committee) and one People's Choice award (selected by conference attendees) — with winning teams receiving recognition and a trophy after lunch on the last day of the show.

Nomination abstracts are due July 30, 2020 and should be emailed to **teri@intuitgroup.com**. More information and Nomination instructions may be found at: **http://speautomotive.com/acce-conference**

ABOUT THE SPE ACCE The ACCE draws over 800 speakers, exhibitors, sponsors and attendees and provides an environment dedicated solely to discussion, education and networking about advances in transportation composites. Its global appeal is evident in the diversity of exhibitors, speakers, and attendees who come to the conference from Europe, the Middle East, Africa, and Asia/Pacific as well as North America. About 20% of the attendees (160 approx.) work for automotive and light truck, agriculture, tuck & bus or aviation OEMs. Approximately 25% (200 approx.) of the attendees work for tiers including molders and material suppliers. The balance of attendees work for composite materials processing equipment, additives, or reinforcement suppliers; trade associations, consultancies, university and government labs; media; and investment banks. The show has been jointly produced by the SPE Automotive and Composites Divisions since 2001.

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. Topic areas 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**.

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WEBSITE REPORT

MARC BAHM, SPE AUTOMOTIVE DIVISION WEBMASTER

Hello fellow SPE Automotive members. I have been responsible for building and maintaining the www.SPEAutomotive.com website for the past three years. I also built and have maintained the SPEDetroit.org website for over six years. During the last two years the speautomotive.com website has been totally rebuilt for a friendly modern website that allows easy visibility for all electronic platforms. Did you know that the **www.speautomotive.com** site receives over 3,000 individual users per month to our site to view content for our newsletter, Innovation Awards Gala, Automotive Composites Conference Exposition (ACCE), golf outing, and other information? Talk about target advertising! You cannot find a better medium to target the automotive plastics community than our website. I personally hope you that you enjoy using our website and go to it often to find out more information about our division and upcoming events. If you would like to find out more information about how your company can become a sponsor/advertiser please contact me and we can discuss the options for displaying your logo with links back to your company website.

Marc.bahm@basf.com or **marc.bahm@gmail.com**

TREASURER'S REPORT

BONNIE BENNYHOFF, SPE AUTOMOTIVE DIVISION TREASURER

AS OF MARCH 27, 2020, THE DIVISION'S ACCOUNT BALANCES WERE:

Checking:	$490,148.73
Savings:	$ 27,487.38
Total:	$517,636.11

SOCIAL REPORT

TERI CHOUINARD, SPE AUTOMOTIVE DIVISION SOCIAL CHAIR

SPONSOR APPRECIATION THANK YOU & CELEBRATION EVENT HELD JANUARY 22

THANK YOU SPE AUTOMOTIVE DIV. PROGRAM SPONSORS AND LEADERSHIP!!

Once again, our SPE Automotive Div. program sponsors and board members (many of our board members are also sponsors :) celebrated the new year together and a year of benefitting SPE student scholarships and programs. This year's sponsor appreciation event, was held on January 22, 2020 at Fogo de Chão Brazilian Steakhouse in Troy, MI. We had a great showing with over 40 attendees from Ford, General Motors, Hyundai, 3M, Ashland, BASF, DSM, DuPont, Fagor Arrasate, JSP, INEOS Composites, Lehvoss, Lotte Chemical, Magna, PCS Company, Ravago Americas, Sabic, Sirmax, Trinseo, and more. A great time was had by all enjoying great food, beverages and industry camaraderie.

Sponsorship support helps us to educate the automotive industry to the benefits of polymer technologies in automotive applications and to provide scholarships and additional support to students interested in careers in the industry. This support helps to grow the industry now and into the future. Thank you to all our sponsors! Your support is greatly appreciated!

2019 GOLF OUTING - 2020 STUDENT SUPPORT

SPE Automotive Div. Golf Outing Supports SPE Student Chapters

The following Michigan Student Chapters benefit:

- Ferris State University
- Kettering University
- Michigan State University
- Mid-Michigan Community College
- Schoolcraft College
- University of Michigan – Ann Arbor
- Western Michigan University
- Oakland University

2019 Golf Outing Proceeds were $3,000 which will be donated to Student Chapters in 2020 with likely additional support again from the SPE Automotive Div.

2019 PLASTIVAN® STUDENT SUPPORT

SPE Automotive Div. Supports PlastiVan® Program Educating Middle and High School Students about Plastics

In 2019 – $28,375 supported 18 visits

Plus 100 Students from Clarkston High School attended PlastiVan® Presentations at SPE ACCE in Sept. 2019

In 2020, We are budgeting close to $40,000 to support 25 visits!

2019 ACCE SCHOLARSHIPS & STUDENT SUPPORT

SPE Automotive Composites Conference & Expo (ACCE) Supports Students Via Scholarships, Travel Stipends & More

- 3 ACCE Scholarships ($2,000 ea.) $6,000
- Dr. Jackie Rehkopf Scholarship $5,000
- Student Poster Competition Scholarships $7,000
- Student Travel Stipends $8,100
- Student Lodging...$10,583

Total Contribution $36,683

2019 SCHOLARSHIPS & STUDENT SUPPORT

The SPE Automotive Division Contributes to Additional Scholarships - Awarded Annually at ANTEC

- Fred E. Schwab Education Award (for Distinguished Professors/Educators)...............$1,250
- SPE International Award (recognizes Lifetime Achievements in Polymer Science).........$1,250
- Support for Students who attended March 2019 ANTEC $5,000

Total Contribution .... $$7,500

* Note: as the 2020 ANTEC was changed to a Virtual Event, support targeted for Student Attendance at the event will be allocated to other programs.

SUMMARY OF SPE AUTOMOTIVE DIVISION 2019 SCHOLARSHIP & STUDENT SUPPORT

- Golf Outing $3,000
- PlastiVan® Program..$28,350
- SPE Automotive Composites Conference & Expo (ACCE)..$36,683
- Additional Scholarships at ANTEC.............................. $7,500
- The SPE Automotive Div. also sponsors 20 students to attend the Innovation Awards Gala annually. At a $200 value for each ticket – this represents an additional $4,000

Total 2019 Scholarships & Student Support Contributions $79,533

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SPE® ANNOUNCES CALL FOR NOMINATIONS FOR 50TH ANNUAL AUTOMOTIVE INNOVATION AWARDS COMPETITION & GALA – *50 YEARS OF PLASTICS INNOVATION*

– MOST INNOVATIVE USE OF PLASTICS AWARD NOMINATIONS – *DUE SEPTEMBER 15, 2020*

– THE TOP 5 MOST INNOVATIVE HALL OF FAME AWARD WINNERS OVER LAST 38 YEARS WILL BE RECOGNIZED

The Automotive Division of the Society of Plastics Engineers (SPE®) is announcing a "Call for Nominations" for its 50th annual ***Automotive Innovation Awards Gala***, , the oldest and largest recognition event in the automotive and plastics industries. This year's Awards Gala will be held **Thursday, November 19, 2020** at the Burton Manor (www.burtonmanor.net) in Livonia, Mich. Winning part nominations ***(due by September 15, 2020)***) in 11 different categories, and the teams that developed them, will be honored during an evening that celebrates automotive plastics innovation. A "Grand Award" will be presented to the winning team from all category award winners. An application that has been in continuous use for 15 years or more and has made a significant and lasting contribution to the application of plastics in automotive vehicles, ***(nominations due by May 29, 2020)*** will be honored with a "Hall of Fame" award.

For more info and to submit nominations go to: **http://speautomotive.com/wp-content/uploads/2020/02/2020-SPE-Innovation-Awards-Program-Part-Nomination-Form-V1.pdf**
Nominations must be submitted online.

To further commemorate ***50 Years of Plastics Innovation,*** the Innovation Awards Gala planning committee is working on special events to celebrate. One of the events will be a special Hall of Fame (HOF) Award honoring the top 5 most innovative HOF winners since the category was established in 1983. Instead of picking a single Hall of Fame Winner for 2020, the HOF committee will determine the top 10 from the previous 38 winners - from 1983 to 2019. Then, the HOF committee will select the top 5 to be honored with special recognition at the event. The criteria for a HOF award is that the nomination be in use for at least 15 years and be: game changing; very successful worldwide; innovative in materials, process and application, and still being used. The HOF committee consists of engineers, managers, executives, technical experts, SPE Fellows, SPE Honored Service Members and automotive industry technical experts having served at least 30 plus years in the industry.

"This year's event will celebrate a half century of automotive advancements enabled by innovative plastics technologies," said Jeffrey Helms, global automotive director, Celanese Corp. who returns as the 2020 SPE Automotive Innovation Awards chair. "As this year is our awards program golden anniversary, we selected ***50 Years of Plastics Innovation*** as our 2020 program theme. In addition to honoring innovation via awards in the different part categories as usual, we will also celebrate our 50th anniversary honoring key innovations in automotive plastics and the many benefits plastics have enabled over the years. This will include advancements in safety, including seat belts, air bags, and sensing devices – all enabled by advancements in plastics technology. The environmental benefits made possible with and by plastics, including improved fuel efficiency, reduced carbon emissions and the growth of automotive innovations with natural and recycled materials for improved sustainability will also be highlighted. Notable innovations in plastics enabled design and styling will also be honored. Society has and will continue to benefit from the ability of plastics to deliver form and function in unique ways through the creativity of automotive engineers and designers."

Since 1970, the ***SPE Automotive Innovation Awards Competition*** has highlighted the positive changes that polymeric materials have brought to automotive and ground-transportation industries, such as weight and cost reduction, parts consolidation, increased safety, and enhanced aesthetics and design freedom. At the time the competition started, in 1970, many OEM designers and engineers thought of plastics as inexpensive replacements for more "traditional" materials. To help communicate that plastics were capable of far more functionality than their typical use as decorative knobs and ashtrays indicated, members of the board of directors of SPE's Automotive Division created the competition to recognize successful and innovative plastics applications and to communicate their benefits to OEMs, media, and the public.

Over the years, the competition drew attention to plastics as an underutilized design tool and made industry aware of more progressive ways of designing, engineering, and manufacturing automotive components. From its humble beginnings, the competition has grown to be one of the most fiercely contested recognition events in the automotive and plastics industries. Today, polymeric materials are no longer substitutes for more expensive materials, but rather are the materials of choice in hundreds of different applications throughout the vehicle. Without plastics, many of the auto industry's most common comfort, control, and safety applications would not be possible.

During the competition phase of the event, dozens of teams made up of OEMs and suppliers work for months to hone submission forms and presentations describing their part, system, or complete vehicle module to support claims that it is the year's ***"Most Innovative Use of Plastics."*** To win, teams must survive a pre-competition review and two rounds of presentations before industry and media judges.

There is no cost to nominate parts, however, nominations that are accepted into the competition need to be presented (in person or via webinar) by their nominating teams during the first round of ***Automotive Innovation Awards Competition*** judging, September 24– 25, 2020 in Auburn Hills, Michigan. Finalists from that round advance to a second presentation before a panel of Blue Ribbon judges made up of media, retired chief engineers, and other industry experts on October 2, 2020 (also in Auburn Hills, Mich.) Winners of each part category, the Grand Award, Hall of Fame, and Lifetime Achievement winner will all be honored during the ***Automotive Innovation Awards Gala*** on November 19, 2020. This annual event currently draws over 800 OEM engineers, automotive and plastics industry executives, and media. Funds raised from the event are used to support SPE educational programs including technical seminars and conferences, which help educate and secure the role of plastics in the advancement of the automobile.

CURRENT COMPETITION CATEGORIES INCLUDE:

- **Additive Manufacturing**
- **Aftermarket & Limited Edition/Specialty Vehicles**
- **Body Exterior**
- **Body Interior**
- **Chassis/Hardware**
- **Environmental**
- **Hall of Fame**
- **Materials**
- **Process, Assembly & Enabling Technologies**
- **Powertrain**
- **Safety**

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. Topic areas include applications, materials, processing, equipment, tooling, design, and development.

For more information about the SPE Automotive Innovation Awards Competition and Gala see **www.speautomotive.com**.. For more information on the Society of Plastics Engineers, see **www.4spe.org**.

Attn: Editors: A large collection of SPE Automotive Division digital photography is available for download at: **https://www.flickr.com/photos/speautomotive/albums**

Shown above are members of the team that developed last year's Grand Award and Body Exterior category winner – the Composite Pickup Box on the 2020 GMC Sierra LD FST pickup from General Motors Co..

CALL FOR NOMINATIONS

— HALL OF FAME AWARD
— MOST INNOVATIVE USE OF PLASTICS AWARDS

The Automotive Division of the Society of Plastics Engineers (SPE®) is announcing a "Call for Nominations" for its 50th-annual ***Automotive Innovation Awards Gala,*** the oldest and largest recognition event in the automotive and plastics industries. This year's Awards Gala will be held Wednesday, **November 19, 2020** at the Burton Manor in Livonia, Mich. Winning part nominations ***(due by September, 15, 2020)*** in 10 different categories, and the teams that developed them, will be honored with a **Most Innovative Use of Plastics** award. A **Grand Award** will be presented to the winning team from all category award winners. An application that has been in continuous use for 15 years or more, and has made a significant and lasting contribution to the application of plastics in automotive vehicles, ***(nominations due by May 31, 2020)*** will be honored with a **Hall of Fame** award.

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POWERTRAIN
SAFETY
HALL OF FAME

SPONSORSHIP OPPORTUNITIES

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

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

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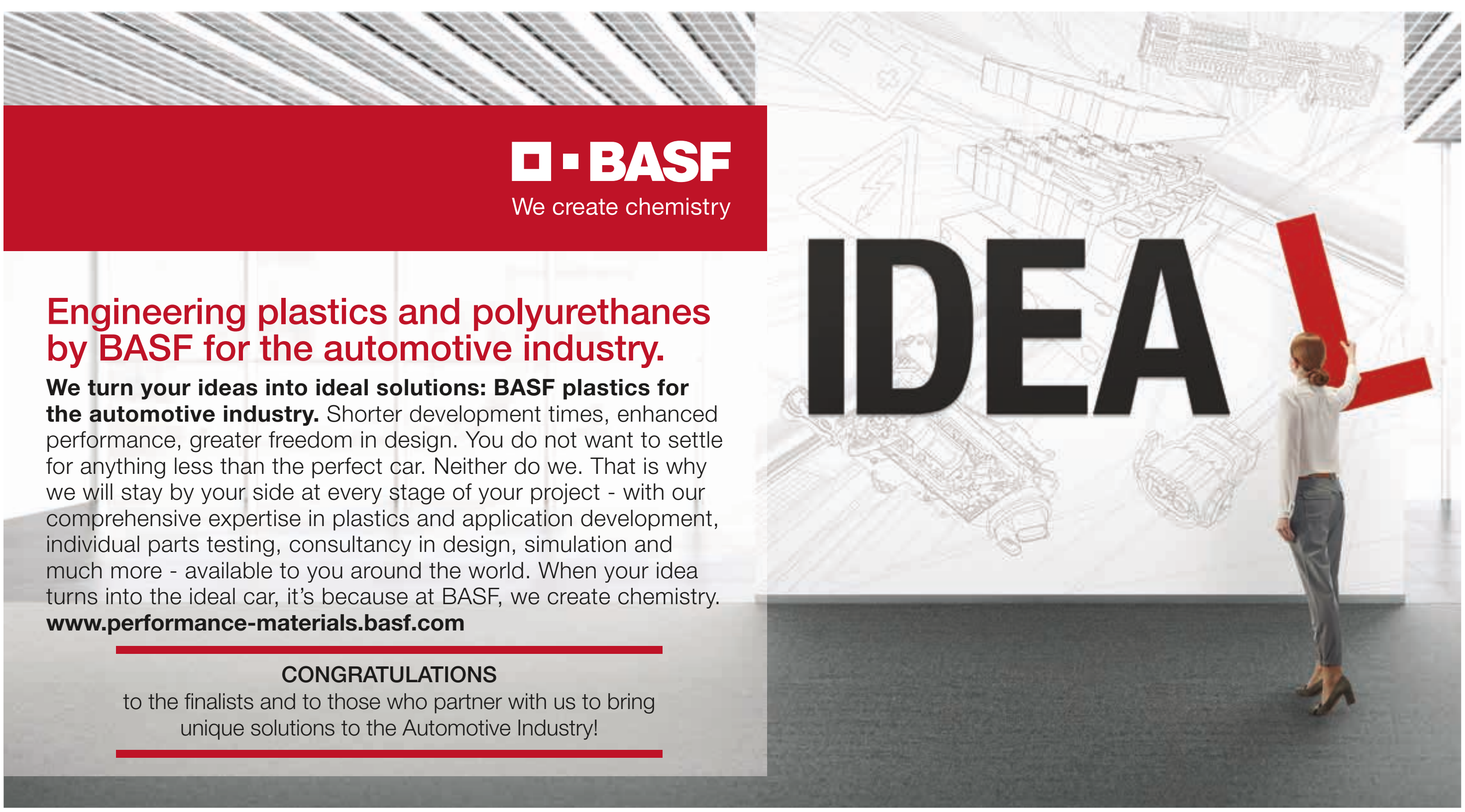
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CONGRATULATIONS
to the finalists and to those who partner with us to bring unique solutions to the Automotive Industry!
IDEAL

AUTOMOTIVE GOLF OUTING

Fieldstone Golf Club • Auburn Hills, MI

Presented by SPE Automotive Division

SEPTEMBER 8, 2020

25 YEARS

25TH ANNUAL SPE GOLF OUTING

SEPT 8

PROCEEDS BENEFIT
SPE STUDENT CHAPTERS
2020 SPONSORSHIP OPPORTUNITES

TYPE OF SPONSORSHIP	COST	BENEFITS INCLUDE
CONTEST HOLE	$1000. USD	1 foursome, signage, flag & more
HOLE	$750. USD	1 foursome & signage
BREAKFAST	$1500. USD	1 foursome & signage with company Logo
LUNCH	$2000. USD	2 foursomes, signage & 100 fliers printed & distributed at the event promoting sponsoring company or its products
DINNER	$3000. USD	3 foursomes, signage, company message / logo on dinner table centerpieces, 100 fliers printed & distributed at the event promoting sponsoring company or its products

COST:
$500. USD/Foursome
$125. USD/Player

PROGRAM:
8:30am: Sign-in & Continental Breakfast

10:00am:
Shotgun Start

Box Lunch at Turn

3:30pm:
Buffet Dinner

4:00pm:
Awards & Prizes

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

http://speautomotive.com/golf

FIELDSTONE GOLF CLUB
1984 TAYLOR ROAD
AUBURN HILLS, MI

2020

2019 SPE TPO AUTOMOTIVE
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INTERSOCIETY REPORT

DR. RODRIGO OROZCO,
SPE AUTO. DIV. INTERSOCIETY CHAIR

ELECTRIFICATION, AUTOMATION, AND A ROADMAP FOR FUTURE MOBILITY ARE THE FOCUS OF RECENT EVENTS OF PLASTICS IN AUTOMOTIVE

2020 began with the Consumer Electronic Show (CES) Vehicle Technology introducing new electric vehicle and concept cars, EV or plug-in hybrid with no internal combustion engine, as well as presenting technological innovations. The most attention grabbing of the technological innovations were: Bosch smart virtual visor that uses a transparent LCD that darkens sections based on the sun shining on the driver's face; BMW ZeroG lounger seat that can recline 40 or 60 degrees including a cocoon-style airbag system and seatbelts that move along with the passenger; Sony exhibited a full electric car designed with Magna with a wall of LCDs across the dashboard; Rivian and Lamborghini announced Amazon Alexa integration for controlling vehicle functions; Continental and Sennheiser presented a speakerless audio system that can emit sound from various surfaces inside the car, and Hyundai and Fisker presented solar panels integrated into the vehicle's roof for electric generation to charge the vehicle's battery.

Vehicle automation was the topic of discussion at the 2020 Mobility Talks International Conference that preceded the Washington Auto Show. Five sessions in the morning followed by four breakout sessions covered the latest trends in connected and autonomous vehicle policymaking and the vision for the future of transportation. One of the main themes in these sessions was the importance for Congress and technology providers to work closely together to define standards for deploying self-driving technology for consumer safety, urban planning and user adoption. A few other topics highlighted in these sessions: clean and safe transportation, US and China automotive relations and their global implications, consumer data and privacy, and how connected and autonomous cars will affect regulation and legislation.

Mr. O'Rielly, Federal Communications Commission (FCC) Commissioner, spoke at the Washington Auto Show's media day about the frustration with the lack of Dedicated Short Range Communications (DSRC) development by the automotive industry taking advantage of the 5.9 GHz spectrum allocated for intelligent transportation services. Cellular vehicle-to-everything (C-V2X) technology, radar and other wireless technologies have been favored over DSRC technologies. Currently, there is no spectrum designated for C-V2X. The automotive industry wants to keep the full 75 megahertz of spectrum to eliminate capacity concerns and prioritize automotive safety related communication from interference in the band.

Also, Eric Meyhofer, CEO of Uber's Advanced Technologies Group, delivered a keynote presentation during the Washington Auto Show's media day and announced the start of Uber's self-driving testing process in Washington D.C. while continuing the testing in Dallas, Pittsburgh, San Francisco, and Toronto. The first phase includes the manually driven street data collection and building high-definition maps for virtual simulations and test track scenarios.

The American Chemistry Council (ACC) Automotive Team developed the new roadmap: Automotive Plastics and Polymer Composites: A Roadmap for Future Mobility. Gina Oliver, senior director of ACC's Automotive Team said "this roadmap provides our industry with a guide for coordinated, cross-sector action that will ensure automakers can create the breakthrough innovations needed to achieve safe, modern mobility solutions".

The roadmap introduces a series of industry-wide, collaborative activities to capture opportunities in each area of the ACCESS framework—Autonomy, Connectivity, Circularity, Electrification, Shared Mobility, and Sustainability. Autonomy refers to ADAS technologies and other developments helping to reduce human drivers from controlling passenger vehicles. Connectivity covers the connectivity and communications that future vehicles will offer for comfort, convenience, and safety. Circularity focuses on recovering materials for refurbishing and repairing materials to extend product lifecycles, and remanufacturing and reusing them in new products. Electrification in vehicles mainly driven by the current and projected sales volumes estimated to represent between 30% and 50% of worldwide vehicle sales by 2040. Shared mobility due to the increased adoption of ridesharing in the last three year, which may help to reduce travel costs and overall environmental impact of passenger vehicles. Lastly, Sustainability as the automakers effort to achieve sustainable designs that reduce environmental impact and improve the product efficiency throughout their lifecycle.

The beginning of 2020 included multiple events that presented innovations in vehicle electrification and automation and active discussions between the private and public sectors to define the development of autonomous vehicle technologies. Currently, the COVID-19 paused many regions in the world with the rapid spread of the virus that affected the supply chain of multiple industries, including automotive. With these current challenges, it will be interesting to see how the second quarter of 2020 evolves.

TECHNICAL REPORT

XIAOMING CHEN, FORD MOTOR COMPANY
CO-AUTHORS: DAVID A. WAGNER AND JOHN UICKER, FORD MOTOR COMPANY
NIKHIL BOLAR, MAGNA, COSMA INTERNATIONAL

Xiaoming Chen is a Technical Expert at Ford Motor Company. Xiaoming holds a Ph.D. in Mechanical Engineering from Northwestern Polytechnical University in China and is an Alexander von Humboldt fellowship recipient.

Xiaoming 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. Xiaoming's current projects are related to lightweight chassis systems and components using advanced high strength steel, aluminum, magnesium and composite materials.

CARBON FIBER SUBFRAME DEVELOPMENT – FATIGUE AND STRENGTH CAE AND TEST RESULTS

ABSTRACT

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.

BACKGROUND AND REQUIREMENTS

Carbon fiber composites are alternatives for lightweight materials in automotive component designs. Carbon fiber reinforced plastic components have been used in luxury cars and racecars. The applications of the materials are mostly unidirectional long fiber composites that provide desired mechanical properties with high cost. The subframe in this research project used EpicBlend SMC, compounded by Magna, a chopped 50k industrial-grade carbon fiber with a modified vinyl ester resin. A continuous carbon fiber material, EpicBlend CFS-Z with $0^0/90^0$ non crimped fabric (NCF), was co-molded with the chopped EpicBlend SMC material. The SMC allows complex geometries. The NCF patches provide strength at critical areas [1]. This approach is affordable and scalable for high-volume production. In addition to the co-molding of the two carbon fiber composite materials, four stainless steel body mount inserts and two stainless steel steering gear compression limiters are over-molded.

A 2016 Ford Fusion was selected as the baseline vehicle for the development. It has a perimeter subframe shown in Figure 1. It is challenging to design a subframe with carbon fiber composites considering its much lower modulus and tensile strength comparing to steels. This carbon fiber composite (CF) subframe design was CAE driven. The stiffness and durability performances of the steel subframe were set as reference targets for the CF subframe design.

The process started with topology optimization for stiffness followed by durability design. Stress in fastener bearing area was also investigated and washers were introduced to prevent composite damage in fastener bearing areas. CAE results demonstrated that the CF subframe met stiffness, durability and strength targets set for the Fusion steel subframe [2].

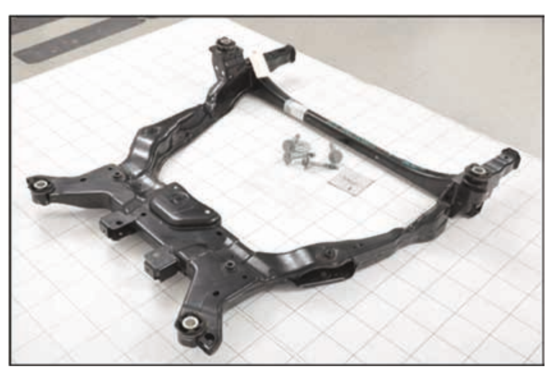

Figure 1: Ford Fusion steel front subframe

To validate the CAE design and prove the quality of the prototype subframe both component and vehicle tests were conducted.

Component tests were conducted to verify the subframe's fatigue performance under high cycle loads and strength under quasi-static loads. There were four loading conditions for fatigue tests and three loading conditions for the strength tests. Under high cycle fatigue loads, the carbon fiber subframes survived the required two accelerated lives. A number of small cracks were observed during the component tests. The majority of cracks did not propagate and the subframes did not lose load carrying capacity. Under quasi-static loads, the subframes exceeded the load carrying capacity requirement for the baseline steel subframe.

Proving ground vehicle durability test and strength related special event tests were also conducted. Numbers of small cracks observed in component fatigue tests did not appear during the vehicle test. There were few cracks in the subframe around the front body mounts and the control arm rear joint. These cracks propagated at certain levels as the test progressed. The cracks did not degrade the subframe's functions on the vehicle. The special event tests included driving over bumps and breaking into potholes. The vehicle passed the Level One test and failed the Level Two test.

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 HIGHLIGHTS

The design of the CF subframe was CAE driven. The CAE design process incorporate the following steps:

TOPOLOGY OPTIMIZATION AND DESIGN FOR STIFFNESS

Topology optimization used the design space to run iterations until the minimal weight was reached and met all stiffness targets set for the optimization. The output of an optimization was a contour plot showing material distribution required to meet all stiffness targets. The topology optimization contour was used to guide the creation of the preliminary subframe design. More CAE iterations were performed to refine the geometries and gauges. Those simulations led to a mature proposal to start durability design iterations. OptiStruct of HyperWorks [3] was the analysis software for this topology optimization and NASTRAN [4] was used for stiffness design simulations.

DESIGN FOR FATIGUE LIFE

Design for fatigue simulates the subframe's working condition with high cycle load cases, such as start, brake, turn, etc. The load input for this CF subframe development is the GEDL (Generic Endurance Design Load) load cases of the baseline steel subframe. There are 13 driving events listed for the simulation. For each event, there are three forces and three moments applied to every chassis component attachment joint of the subframe. The load cases represent 150,000 miles or 10 years' service of the vehicle. Figure 2 is the plot of the braking event with 20 cycles.

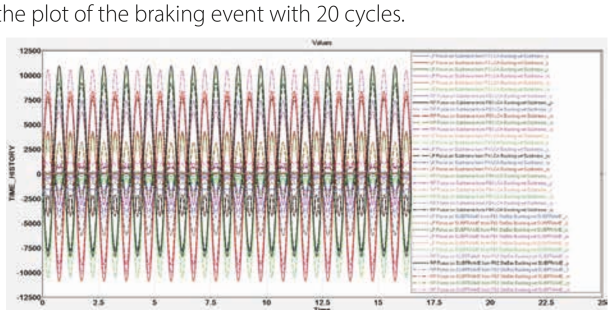

Figure 2: braking event loads applied to joints

There were two steps to simulate the subframe's fatigue life with CAE. Step 1 ran NASTRAN analysis with unit loads applied to joints. The output of the analysis was stresses in the structure. Step 2 used nCode [5] combining NASTRAN output and GEDL load cases as input. The minimal CAE-based life prediction required for production subframes is two lives. CAE simulation did not identify any location with fatigue life less than two (2.0 lives) demonstrating that the subframe met GEDL load design targets.

DESIGN FOR STRENGTH

The strength design of the subframe is for structure integrity under extreme loading conditions. The production subframe's GSS (Global Suspension Strength) load cases were used for the carbon fiber composite subframe's strength design. There are two levels of load inputs for this design process. Level One loads represent moderate abuse such as driving through bumps. Measurements of Level One performance is the structure permanent deformation. Ford's requirement is that the subframe remain completely functional after multiple Level One events. For ductile material subframe, this requirement limits the permanent deformation to less than one or two millimeters depending on location. Level Two loads represent extreme abuse such as braking into potholes. Measurements of Level Two performance is the structure damage. Ford's requirement is that the subframe remain completely functional, though likely in need of repair, after multiple Level Two events. The subframe must maintain function without any separations or loss of integrity. ABAQUS [6] was the analysis software. Under Level One loading the design criteria for steel subframes are permanent deformations (deformation after unloading) listed as following:

- Permanent deformation < 1 mm at loading points
- Permanent deformation < 2 mm at rest of the subframe

Under Level Two loading the design criterion for steel subframes limits the plastic strain as following:

- Max. plastic strain of the subframe < 50% of the failure strain of the alloy

Since carbon fiber composites have little or no ductility, the failure criteria under both Level One and Level Two loads are defined as following:

- SMC: Max stress > yield stress (187 MPa)
- Laminates: Tsai-Hill criteria predicted failure

$$\frac{\sigma_{11}^2}{S_{11}^2} - \frac{\sigma_{11}\sigma_{22}}{S_{11}^2} + \frac{\sigma_{22}^2}{S_{22}^2} + \frac{\sigma_{12}^2}{S_{12}^2} \geq 1.0$$

CAE simulation results showed stress of SMC is lower than the yield stress. The Max. Failure Index on the control arm front joint laminates is 1.6 indicating concern at that location (Figure 3). It requires verification by tests.

Figure 3: CAE predicted failure on control arm front joint laminate

DESIGN FOR BOLT LOAD RETENTION

Subframe joints for the attached chassis components are bolted joints. This CF composite subframe has M14 and M16 bolts (bolts shank diameters are 14mm and 16mm respectively). The proof loads for M14 and M16 bolts are 95.5kN and 130kN. High bolt proof loads could lead to high stresses in fastener bearing area. Yield or any composite damage of fastener bearing area could affect bolt load retention of the joint.

A common practice to reduce the stress level in fastener bearing area is to add washers. Washers create an effective stress bearing area that is larger than the fastener bearing area. Dimensions of washers are decided by bolt proof loads, the size of fastener bearing area and the yield stress of the subframe material [7]. Washers are introduced to all joints of the CF composite subframe except for the control arm rear joint, which has the bushing brackets covering large areas at and around the joints.

Most washers in the CF composite subframe are "Hat" washers. "Hat" washers cover the top surfaces of bolt holes and small portion of the side wall of bolt holes. "Hat" washers are made of the same steel and have the same finish as for bolts, which is one of the corrosion mitigation strategies in addition to its bolt load retention function. Figure 4 is the control arm front joint with four "Hat" washers.

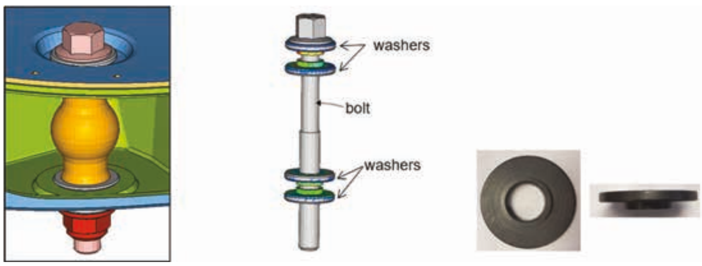

Figure 4: control arm front joint with "Hat" washers

ABAQUS was used to run the fastener bearing area stress analyses. The failure criteria are the same as those for strength design iterations. The control arm front joint surfaces were identified by CAE simulations as areas of concern (Figure 5). The high stress were on laminates. It needs to be verified by tests.

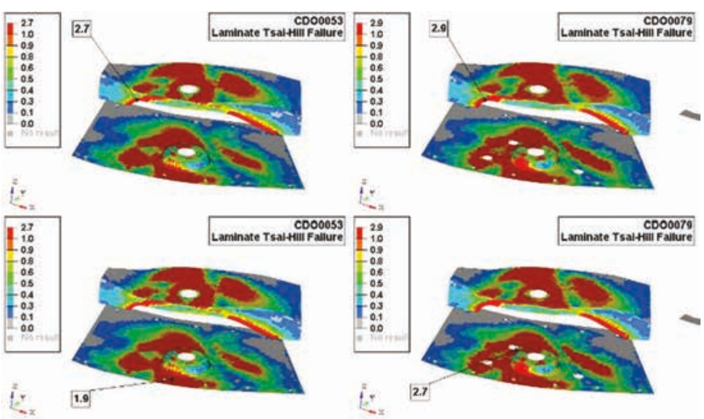

Figure 5: control arm front joint laminate surfaces

CF SUBFRAME PROTOTYPE

The CF composite subframe prototypes are produced by Magna International. The subframe utilizes an industrial carbon fiber compounded with a modified vinyl ester resin system in EpicBlendTM CFS-Z SMC that is approximately 50% by weight chopped carbon fiber. The second carbon fiber composite material that is co-molded with the SMC is a pre-preg material that utilizes continuous 0º/90º non crimped fabric that is approximately 56% by weight continuous oriented carbon fiber. The design and combination of materials achieves a 7.3 kg (28%) mass reduction over a stamped steel subframe. The subframe achieves an 82% part reduction by replacing the 45 steel parts with two molded parts that incorporate six over molded steel parts. The two moldings, an upper clamshell and a lower close out panel, are joined be adhesive bonding and structure rivets. Details of the subframe components are shown in Figure 6.

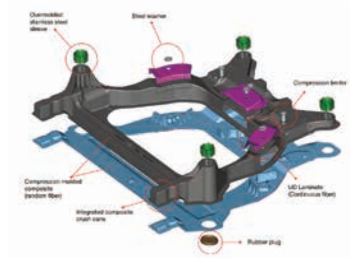

Figure 6: CF composite subframe components

Figure 7: CF The finished part - composite subframe prototype part

CARBON FIBER COMPOSITE SUBFRAME COMPONENT FATIGUE TESTS

Subframes were tested to validate the CAE design and prove the quality of the CF composite prototype. Tests included component durability under fatigue loads and strength under static loads. The fatigue tests were conducted for all four joints of the subframe. A steel subframe was also tested for each setup. The load cases were developed based on the GEDL loads (Generic Endurance Design Loads) of the surrogate part. CAE were conducted to simulate the tests. The outputs were compared with test results. The CAE predictions did not correlate with test results.

ROLL RESTRICTOR FATIGUE TEST PROCEDURE

The subframe was mounted to the bedplate in vehicle position utilizing the body mounts as shown in Figure 8. Horizontal longitudinal block cycle loads were applied 90 degrees to the roll restrictor bushing fastener through a solid loader. The height of the loader was equal to that of the roll restrictor. Lower arm bushings were bolted in the lower arm pockets on all samples. Horizontal sinusoidal loads of two baseline lives and eight over stress loading blocks were generated from production Fusions' GEDL roll restrictor load events.

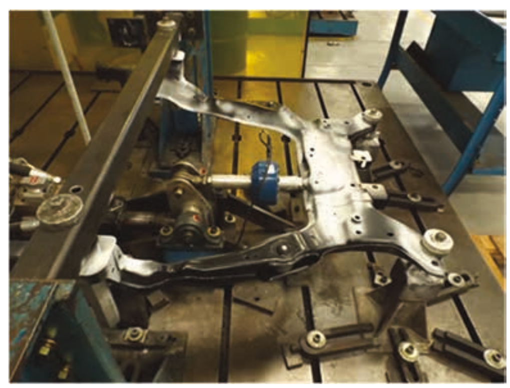

Figure 8: roll restrictor test setup

ROLL RESTRICTOR FATIGUE TEST RESULTS

A single steel subframe was tested through two baseline-loading cycles (two lives) and seven over stress cycles. There was no damage detected.

The CF subframe was also tested for two baseline cycles and seven over stress loading cycles. There was visible damage, i.e., small cracks, but without loss of function or load carrying capacity.

For the carbon composite subframe samples, several small cracks were observes through the loading process. Most of the cracks were on the front body mount surfaces. Few were near the loading location and the control arm rear joint (Figure 9). Some cracks were detected before the end of the second baseline cycle. All cracks were stabilized as the loading progressed. The subframe structure maintained its integrity and load carrying capacity through the test. This component test result proved that the CF subframe met the fatigue requirements at the roll restrictor joint.

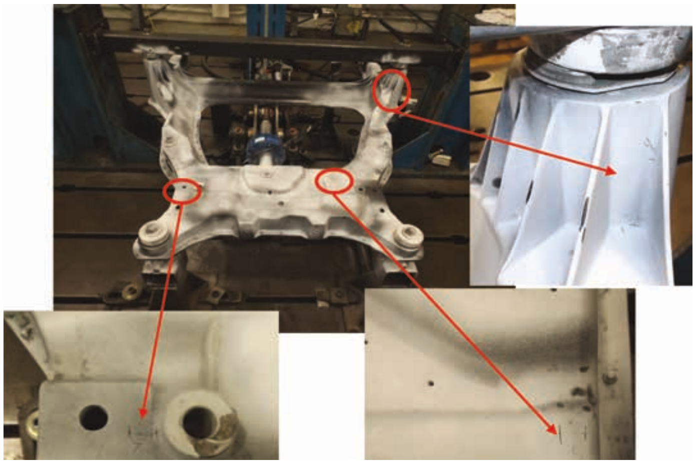

Figure 9: roll restrictor test cracks - CF subframes

FRONT LOWER CONTROL ARM FATIGUE TEST PROCEDURE

The subframes were secured to a fixture which was rigidly bolted to the bedplate. A longitudinal and a lateral actuator were connected to the ball joint stud of the left and right lower control arms shown in Figure 10. Loads were applied into the subframe by block cycles. Inspections were made periodically throughout the test to look for cracks in the subframe.

A calibrated Flextest controller was used to control the load of all four hydraulic actuators. Loads were applied in a sinusoidal wave based on the block cycles generated from production Fusions' GEDL control arm load events.

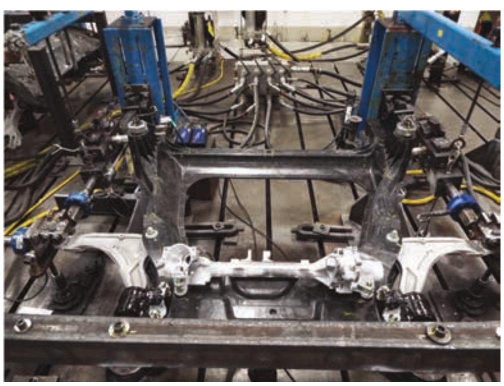

Figure 10: control arm test setup

FRONT LOWER CONTROL ARM FATIGUE TEST RESULTS

TThe steel subframe was tested through two baseline-loading cycles (two lives). Cracks were detected before completing the second baseline loading cycles (Figure 11)

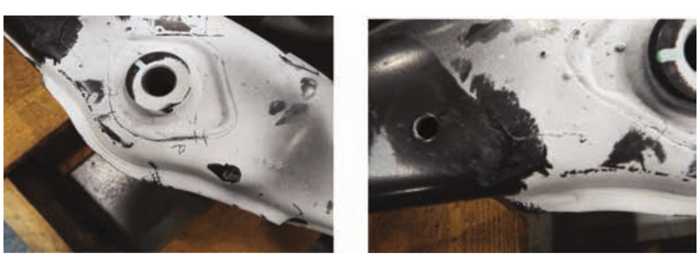

Figure 11: control arm test cracks – steel subframe

The CF subframe was also tested for two baseline cycles. For the three carbon fiber composite subframe samples, multiple small cracks weredetected. Some initiated at the early loading blocks. Most of the cracks were around the front body mounts. Propagations were observed as the test progressed. Selected cracks are shown in Figure 12. The subframes survived the two baseline loading cycles without losing its load carrying capacity.

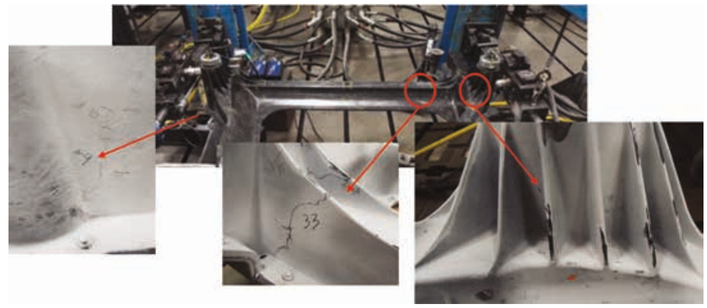

Figure 12: control arm test cracks –CF subframe

STABILIZER BAR FATIGUE TEST PROCEDURE

The CF subframe was mounted level to the bedplate as shown in Figure 13. The subframe was loaded through the stabilizer bar brackets and bushings. The test load was applied 90 degrees to level using a production stabilizer bar. Lower control arm bushings and a roll restrictor were bolted in place, and a steering gear was mounted to each frame tested. Sinusoidal Block cycle test loads were applied. The two actuators were run 180 degrees out of phase at 2.0 Hz with the two baseline lives and four over stress loading blocks generated from production Fusions' GEDL stabilizer bar load events.

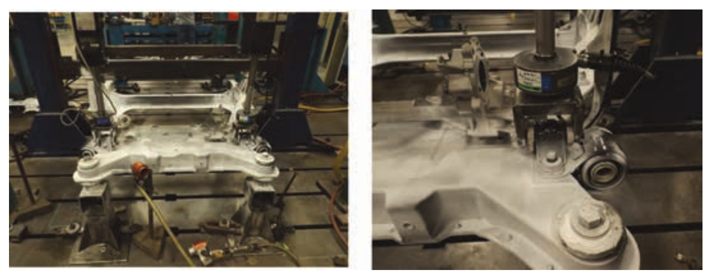

Figure 13: stabilizer bar test setup

STABILIZER BAR FATIGUE TEST RESULTS

One steel subframe was tested through two baseline-loading cycles (two lives) and four over stress cycles. There was no damage detected. For the three CF subframe samples, cracks initiations were detected close to the finish of second baseline cycles. More small cracks were observed through over stress loading. Several cracks were around the front body mounts and other cracks were scattered throughout the subframe. Most cracks did not propagate. Selected cracks are shown in Figure 14. The subframes successfully passed the two baseline loading cycles and four over stress cycles without losing its load carrying capacity.

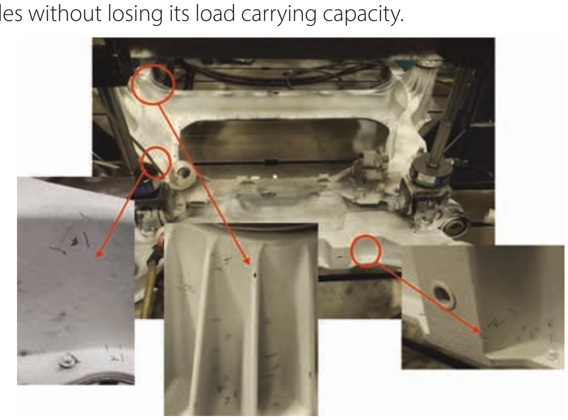

Figure 14: stabilizer bar test cracks –CF subframe

STEERING GEAR FATIGUE TEST PROCEDURE

The CF subframe was mounted level to the bedplate as shown in Figures 15. The subframe was loaded through a steering gear housing using simulated tie rod ends. The load axis was 6 degrees forward and 6 degrees down at outer tie rod ball joints, 26 mm from the ends of the housing. Lower arm bushings and a roll restrictor were placed in their respective locations and bolted into place.

The two actuators were run 180 degrees out of phase such that when the Left Hand load cell was in tension, the Right Hand load cell was in compression. Block cycle loads were applied with two baseline lives and eleven over stress generated from production Fusions' GEDL steering load events.

Figure 15: steering gear test setup

STEERING GEAR FATIGUE TEST RESULTS

One steel subframe was tested through two baseline-loading cycles (two lives) and eleven over stress cycles. There was no damage detected.

Multiple crack initiations were detected on each of the three CF subframe samples before the completion of second baseline cycles. Cracks were at or close to the steering gear attachment joint. The cracks did not propagate much. Selected cracks are shown in Figure 16. The subframes passed the two baseline loading cycles and eleven over stress cycles without losing its load carrying capacity.

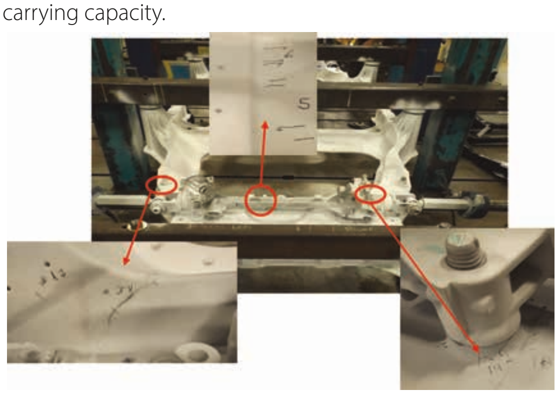

Figure 16: steering test cracks – CF subframe

VEHICLE HIGH CYCLE DURABILITY TEST

A carbon fiber composite subframe was installed in a production Fusion and tested at Ford Michigan Proving Ground. The test followed the Ford procedure which is one of several tests required for passenger cars, crossovers and utility vehicles. The test emphasizes accelerated vehicle body and chassis systems and component durability based on customer correlated public road usage [8].

The vehicle was inspected daily through the three month test duration. The inspections evaluated part condition and visually inspected the paint marks on the subframe joints to detect possible bolted fastener movements. The vehicle durability test results were contrary to the component fatigue tests. Scattered small cracks were not observed through the test. Few cracks were detected. The crack on the front body mount was found at the very early stage of the test. It propagated and stabilized at about 25% of the test duration. Other cracks were recorded at about 50% of the test duration. They remain the same lengths until the end of the test. The cracks are shown in Figure 17.

Figure 17: cracks – vehicle durability test

The vehicle completed required test conditions and cycles. No degradation of functions was detected. The post-test inspection, Figure 18, did not find visible movement of fasteners. The Fusion vehicle with a CF composite subframe successfully passed the proving ground durability test.

Figure 18: CF subframe – post vehicle durability test

CARBON FIBER SUBFRAME COMPONENT STRENGTH TESTS

The strength tests were conducted to evaluate the load carrying capacity of the CF subframe. Three loading conditions were designed. Fixtures were built for each of the tests. The subframe was secured at the four body mounts shown in Figure 19. The subframes were loaded under quasi-static loads up to failure occurred and compared with the surrogate vehicle's GSS loads (Global Suspension Strength) at the loading joints.

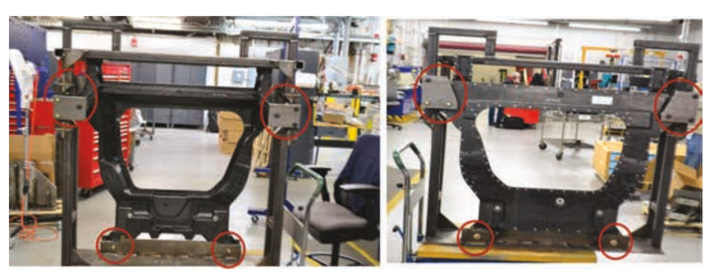

Figure 19: CF subframe – Strength test fixture

CAE simulations were done before the tests to predict failure locations and peak loads. CAE simulation results also helped to choose load cells for the tests. ABAQUS was used for CAE simulations.

ROLL RESTRICTOR STRENGTH TEST SETUP

For the roll restrictor test, a steel tube was used to represent the roll restrictor bushing. The load was applied in the vehicle's longitudinal direction shown in Figure 20.

Figure 20: Strength test – roll restrictor loading

ROLL RESTRICTOR STRENGTH TEST RESULTS

The failure started at the loading location. The bolt hole of the roll restrictor was damaged. The bolt was bent and the nut was broken shown in Figure 21. The force curve is shown in Figure 22. The peak load is about 80 kN.

Figure 21: strength test – roll restrictor loading damage

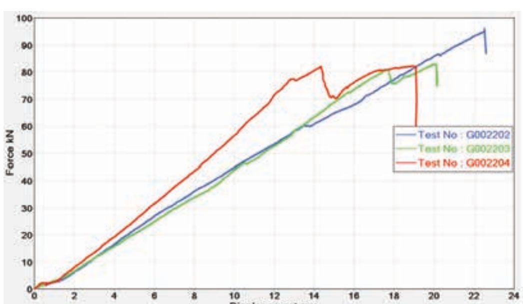

Figure 22: Strength test – roll restrictor loading force deflection plot

ROLL RESTRICTOR STRENGTH TEST & CAE COMPARISON

The test results were compared with CAE predictions. The ABAQUS simulation predicted high stress area at the edge of the bolt hole that is the same location showing failure in the tests (Figure 23). The peak load predicted by the simulation is higher than the failure load of the test.

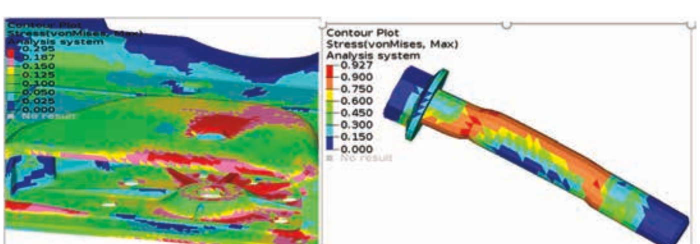

Figure 23: Strength test – roll restrictor loading CAE failure locations

CONTROL ARM FRONT JOINT STRENGTH TEST SETUP

For the control arm front joint test, a steel tube was used to represent the control arm bushing. The load was applied in the vehicle's lateral direction shown in Figure 24.

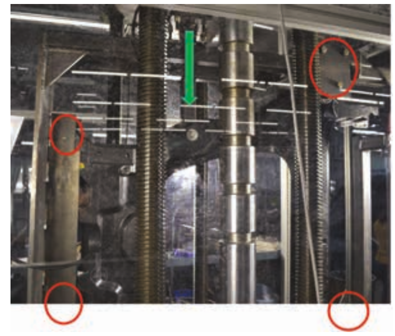

Figure 24: Strength test – control arm front joint loading

CONTROL ARM FRONT JOINT STRENGTH TEST RESULTS

The damage started near the loading location. There was a crack on the opposite side of the loading point. Figure 25 shows cracks on the subframe. The force curve is shown in Figure 26. The peak loads of the test are higher than 58 kN, the GSS resultant load at this hard point.

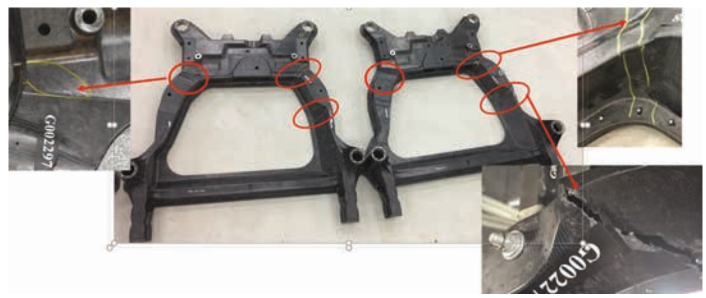

Figure 25: strength test – control arm front joint loading damage

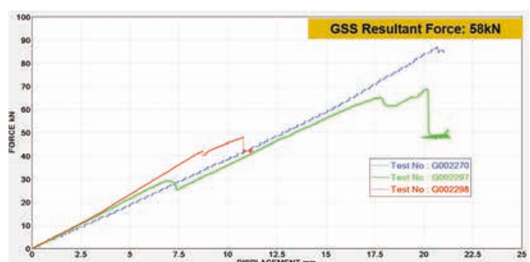

Figure 26: strength test – control arm front joint force deflection plot

CONTROL ARM FRONT JOINT STRENGTH TEST & CAE COMPARISON

The test results were compared with CAE predictions. The ABAQUS simulation predicted high stress areas near the loading point that are the same locations showing failures in the tests (Figure 27). The CAE simulation did not catch the crack on the opposite side of the loading point. The peak load predicted by the simulation is higher than the failure load of the test.

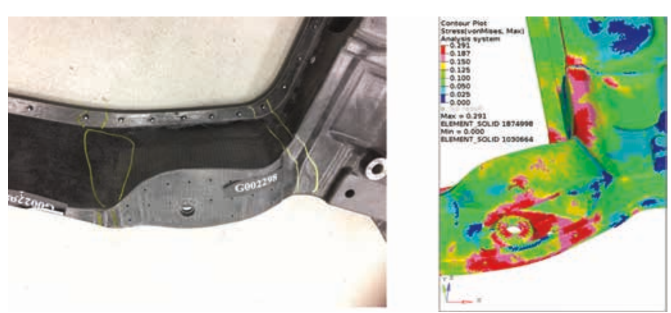

Figure 27: Strength test – control arm front joint loading CAE failure locations

CONTROL ARM REAR JOINT STRENGTH TEST SETUP

For the control arm rear joint test, A "U" bracket was used to represent the control arm bushing bracket. The load was applied to the lateral direction of the vehicle shown in Figure 28.

Figure 28: Strength test – control arm rear joint loading

CONTROL ARM REAR JOINT STRENGTH TEST RESULTS

The damage started near the loading location. Figure 29 shows cracks on the subframe. The force curve is shown in Figure 30. The peak loads of the test are much higher than 35 kN, the GSS resultant load at this hard point.

Figure 29: strength test – control arm rear joint loading damage

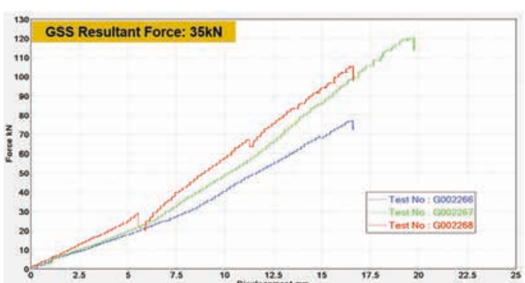

Figure 30: strength test – control arm rear joint force deflection plot

CONTROL ARM REAR JOINT STRENGTH TEST & CAE COMPARISON

The test results were compared with CAE predictions. The ABAQUS simulation predicted the high stress area near the rear body mount that is the same location showing a crack in the tests (Figure 31). The CAE simulation did not catch the crack between the control arm front and rear joints. The peak load predicted by the simulation is higher than the failure load of the test.

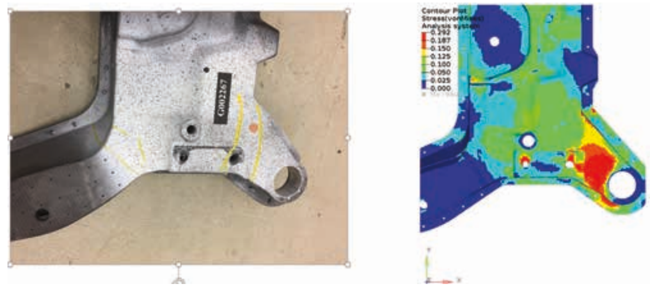

Figure 31: Strength test – control arm rear joint loading CAE failure location

VEHICLE SPECIAL EVENT TESTS

The proving ground special event test is intended to examine the effect on suspension, steering and affected body components, when subjected to shock loading as experienced when driving over curbs and braking into potholes. This procedure is part of a set of tests which evaluate the effect of severe driving maneuvers to a worldwide passenger cars, CUV's, Mustang, police cars and small sport utility vehicles [9].

The test results stated that the Fusion with a CF subframe passed the Level One test. No damage was observed at the completion of the Level One test. The vehicle did not pass the Level Two test. The subframe was damaged at one of the braking into pothole runs. The post-test photo is shown in Figure 32.

Figure 32: CF subframe – post vehicle special event test

The CAE driven design process did not simulate this dynamic loading event. This damage was not anticipated based on our knowledge with steel subframes and early development of other lightweight research subframes. We learned from this incident that a CAE procedure is necessary to analyze the response of CF chassis components under underbody impact loading.

SUMMARY

A carbon fiber composite research subframe was developed based on Ford Fusion's package space. The prototype subframe was compression molded with EpicBlend SMC, a chopped 50k industrial-grade carbon fiber with a modified vinyl ester resin. EpicBlend CFS-Z with $0^0/90^0$ NCF, was co-molded with the chopped EpicBlend SMC material. The design was CAE driven. CAE design iterations demonstrated that the CF subframe met stiffness, durability and bolt load retention performance requirements.

Both component and vehicle tests were conducted to verify the design and build of this industry first CF composite subframe.

Component fatigue tests produced multiple cracks on the subframe. Most of the cracks are small. The cracks stabilized at certain points of the tests. All tests passed the required two lives loading cycles without losing load carrying capacity. CAE simulations did not correlate with test results.

The vehicle high cycle durability test was successful. It produces less than five cracks. The cracks propagated and stabilized as the test progressed. The vehicle maintain all functions through the test. No fastener torque loss was observed after the test. CAE simulations did not correlate with test results.

Component strength tests were completed with satisfied results. The peak loads exceeded the GSS loads at all tested hard points. CAE predictions captured most failure locations. CAE predicted peak loads were higher than test loads.

The Vehicle special event Level one test was completed. The vehicle did not pass the Level Two tests.

One of the challenges of the CF subframe design was the material input for CAE simulations. More efforts are needed to create material models for CF composite analyses.

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