Abstracts of Speaker Presentations 2015

WEDNESDAY, SEPTEMBER 9

— IN ONYX ROOM —

Additive Manufacturing & 3D Printing - Part 1 of 2: *Additive Manufacturing*

James Orrock, Stratasys Inc.

Additive Manufacturing Composite Materials for Automotive Product Development

Today's 3D printing materials are suitable for prototyping and functional testing of many part types, such as interior trim panels, engine induction systems, and passenger compartment ducting. With the introduction of new high-strength, high-modulus, and high-temperature composite materials for additive manufacturing systems, the application scope can increase significantly to include part types such as exterior body panels, underbody panels, underhood components, and new types of tooling.

Ellen Lee, Ford Motor Co.

New Materials and Processes for Additive Manufacturing for Automotive Applications

As technologies for additive manufacturing continue to evolve, Ford Motor Co. is moving beyond prototyping towards functional, durable materials and applications. Here we discuss a new process under evaluation that can enable production of robust components for automotive use.

Vlastimil Kunc, Oak Ridge National Laboratory

Advances and Challenges in Large Scale Polymer Additive Manufacturing

Additive manufacturing of large polymer structures has recently been demonstrated by printing of several full-size cars. The focus of this presentation is on the key aspects that make this technology feasible as well as challenges standing in the way of its widespread application. The most recent a dvancements and challenges in printing with fiber-reinforced polymers, temperature profile control, and software integration will be examined.

Additive Manufacturing & 3D Printing - Part 2 of 2: *3D Printing*

Bryan Crutchfield, Materialise NV

3D Printing: A Game Changer for Manufacturing

3D Printing is not only changing the way parts are manufactured, but also changing the manufacturing processes used to produce them. This presentation will cover how 3D printing and 3D-printed fixtures, part locators, and attribute check features are helping manufacturing companies reduce lead times and tooling costs, and helping to improve quality.

Umesh Gandhi, Toyota Research Institute North America

Designing Lattice Structure for 3D Printing

In this paper a methodology to design, optimize, and evaluate periodic lattice-based cellular structures, which can be manufactured using 3D printing, is presented. Non-linear finite-element models of the lattice design for simulation are developed and compared with 3D-printed physical parts to verify the approach.

Mike Lee, AlphaStar Corp.

The Impact of Fiber Content & Effect of Defects on 3D Printing Car Additive Manufacturing Processes

Additive manufacturing is distinguished from traditional manufacturing techniques such as casting and machining by its ability to handle complex shapes with great design flexibility and without the typical waste associated with the other processes. Fused deposition modeling (FDM), a leading rapid prototype technique, accomplishes the layer-by-layer build by depositing a material extruded through a nozzle in a raster pattern in each layer. The objective of this work was to determine the impact of fiber content and effect of defects such as void and fiber waviness on quality of a 3D printed car using the additive manufacturing processes.

Advances in Thermoset Composites – Part 1 of 2:

Michael Sumner, Ashland Inc.

Development of Ultra Low Density SMC

There is a very-high interest in "lightweighting" in the automotive industry due to pending CAFE 2025 regulations to increase fuel economy. Over the past few years, developmental efforts have resulted in 1.2-specific gravity systems with a good balance of both surface quality and mechanical properties. However, there is considerable interest in driving the specific gravity to 1.1, and preferably lower, for further weight reduction and to compete more effectively on a cost basis with aluminum. Product development efforts that have resulted in tough Class A SMC with a density of less than 1.2 will be presented.

Markus Downey, Michigan State University
2014-2015 ACCE scholarship winner

Toughening of Aromatic Epoxy Polymers via Aliphatic Epoxy Monomer Addition: Optimized Fiber-Reinforced Polymer Composites for Lightweighting

Aliphatic epoxy polymers are shown to enhance the Mode I fracture toughness of aromatic-based carbon fiber-reinforced composites. As a 1-wt% concentration copolymer in the matrix, a 35% enhancement in fracture toughness is seen. Used as fiber sizing, aliphatic epoxy shows a 50% increase in fracture toughness, without affecting other composite properties.

Thermoset Composites Roundtable Discussion

Abstracts of Speaker Presentations 2015

— IN OPAL/GARNET ROOM —

Virtual Prototyping & Testing - Part 1 of 5: *Impact Testing*

Loleï Khoun, National Research Council Canada (NRCC)

Impact Behaviour of Thin Carbon Fibre Reinforced Composites Components for Automotive Applications

As carbon fiber-reinforced composite materials are being used more often in automotive components for structural, semi-structural and body panels, it becomes important to understand their behavior under impact loading better, especially for part design and passenger and pedestrian safety. Low-velocity impact tests were performed to investigate the impact behavior of thin carbon fiber-reinforced composite laminates and determine damage mechanisms and damage energy thresholds. Two 2.5-D numerical approaches were developed and correlated to experiments to be used as design tools for carbon fiber reinforced composite components subjected to impact design requirements.

Robert Yancey, Altair Engineering

Designing Composite Structures for Impact Performance – What Can We Learn from the Aerospace Industry?

Simulating the response of metallic structures to automotive crash scenarios is well developed and well accepted. As the automotive industry adopts the use of more composites, a similar confidence is required for simulating the crash response of composite materials. A review of simulation modeling methods for impact scenarios in aerospace and automotive applications will be reviewed along with a discussion of what each industry can learn from the other in the impact modeling and simulation of composite structures.

Stuart Brown, Veryst Engineering, LLC

Impact Testing of Fiber-Reinforced Thermoplastics

Fiber-reinforced thermoplastics are used in a wide range of automotive applications involving impact loading. We will present results for the tensile and compressive stress-strain response of a fiber-reinforced thermoplastic over a large strain-rate range, varying from 0.001 sec^{-1} to 1500 sec^{-1}. We discuss the complications of obtaining these data and how one method may be superior to another.

Virtual Prototyping & Testing - Part 2 of 5: *Fabric Weaves*

Dustin Souza, e-Xstream engineering

Prediction of Post Failure Behavior of Woven Made Parts for Crash Design Needs

A complete workflow based on simulation to support the development of woven composites in the automotive industry is described. Three steps are covered: stiffness calibration, progressive damage-behavior calibration, and validation at the coupon level. Once these steps are achieved, application to a real case (a crash box) is performed.

Sarah Stair, Baylor University

2013-2014 ACCE scholarship winner

Investigation of Woven Fiber Reinforced Laminated Composites Using a Through Transmission Ultrasonic Technique

Carbon fiber-reinforced laminated composites often produce materials with a high strength to weight ratio, but the manufacturing and repair of these materials is often more complicated than that of metals. While nondestructive evaluation methods, such as ultrasound, are able to identify defects or damage within a part, there is a need for a nondestructive testing method that can identify how the defect or damage affects the resulting strength of the part. The natural complexity of the fiber-reinforced laminate increases the difficulty of determining such information via ultrasound because the fibers and polymer matrix scatter the ultrasound wave as it travels through the thickness of the laminate. The new through-transmission ultrasound technique presented in this study is applied to a laminated composite consisting of woven carbon fiber material. The results provide the ratio of the shear to the longitudinal wave speeds within the laminate, which may be applicable for use with the Christoffel Equation to identify the planar stiffness components. Additional results demonstrate how this technology may also be applied to laminates bonded to another material, such as aluminum.

Neal Corey, Ford Motor Co. & **Ankur Bhosale,** BASF Corp.

MMLV Lightweight Powertrain – Long Carbon Fiber Structural Front Cover & Oil Pan

This presentation outlines the joint collaborations of Ford RIC (Research & Innovation) along with the BASF Performance Materials teams on lightweighting initiatives targeted towards optimizing the mass of the powertrain on the Multi Material Lightweight Vehicle (MMLV) platform. The MMLV developed by Magna International and Ford Motor Co. is the result of a U.S. Department of Energy project DE-EE0005574. The project demonstrates the lightweighting potential of a 5-passenger sedan while maintaining vehicle performance and occupant safety. Prototype vehicles were manufactured and limited full vehicle testing was conducted. The Mach-I vehicle design, comprised of commercially available materials and production processes, achieved a 364 kg (23.5%) full vehicle mass reduction, enabling the application of a 1.0-liter three-cylinder engine resulting in a significant environmental benefit and fuel reduction. Both the composite front cover and oil pan structural components were designed, and developed using a 50% long-carbon fiber (LCF) product. The final components, helped achieve a substantial weight savings vs. aluminum counterparts while meeting the functional requirements based off the production Ford 1.0L I3 EcoBoost engine.

Virtual Prototyping & Testing - Part 3 of 5: *Draping & Joining Simulation*

Ian Swentek, Fraunhofer Project Centre for Composite Research at the Western University

Investigation on Fiber Preforming with Draping Simulation

A new software, Aniform is used to conduct preform simulations with the double-dome geometry. The simulation is designed to predict the blank shape and wrinkle formation from phenomenological fabric properties. The work first highlights methods to optimize the simulation. Draping simulations are conducted to mirror experimental tests and the results are discussed.

Steffen Ropers, Volkswagen Group Research
Márton Kardos, University of Applied Sciences Hof
2015-2016 ACCE scholarship winner

Material Characterization and Draping Simulation of Thermoplastic Prepregs: The Influence of Temperature

The potential of dynamic mechanical analysis (DMA) was investigated as an effective method to characterize the temperature dependency of mechanical properties of thermoplastic prepregs. A sensitivity analysis based on the design of experiments (DoE) approach was conducted to identify parameters with major effects on blank temperature in draping simulations. The resulting major parameters were combined with temperature-dependent mechanical properties as parameters for a subsequent DoE to identify their effect on the shear angle. Here, DMA results were used to calibrate temperature-dependent mechanical properties.

Yuyang Song, Toyota Research Institute of North America

Finite Element Modeling for Adhesive Joint of Dissimilar Materials

A finite-element method is introduced to predict the adhesive joining of composite materials. Standard lap shear and peel tests are conducted and the adhesive properties are estimated using reverse engineering. The estimated properties and the finite-element analysis (FEA) modeling approach are validated on a 3D part under complex loading conditions. Such FEA modeling methods will benefit future projects involving the joining of dissimilar materials in vehicle components.

— IN EMERALD/AMETHYST ROOM —

Nanocomposites - Part 1 of 3: *Cellulose & Nanocellulose*

Mehdi Tajvidi, University of Maine

Transparent Composite Films of All-Cellulose and Cellulose-Polyvinyl Alcohol Nanocomposites: Effect of Relative Humidity and Temperature on Mechanical Performance

The two main forms of cellulose nanomaterials namely, cellulose nanocrystals (CNC) and cellulose nanofibrils (CNF) are known as high strength, high stiffness renewable nanomaterials of the future. However, most information available on the mechanical performance of these fibers and their composites comes from testing at room temperature and 50% relative humidity. This research presents our findings on mechanical properties of these materials as affected by temperature and relative humidity.

Kim Nelson, American Process Inc.

Lightweighting Vehicles with BioPlus™ Nanocelluose Composites

Cellulose nanomaterials, including cellulose nanocrystals (CNC) and cellulose nanofibrils (CNF), are extremely strong, and also biobased, renewable, and nontoxic. Cellulose nanomaterials can provide reinforcement and improved barrier properties in polymer composites, hydrogels, and aerogels with materials such as polypropylene, polyester, nylon, and polylactide for automotive applications. Major challenges are cost and compatibility with hydrophobic polymers. This presentation will describe a new process that meets these challenges.

Shokoofeh Ghasemi, University of Maine

Cellulose Nanoparticle Reinforced Polyurethane Foams

We are presenting a new application of cellulose nanocrystals (CNC) and cellulose naofibrils (CNF) in foam structures made of polyurethane (PUR). Different percentages of CNC and CNF were added to PUR and foam properties were studied using scanning electron microscopy (SEM), image analysis, atomic force microscopy (AFM), dynamic mechanical analysis (DMA), and thermogravimetric analysis (TGA).

Nanocomposites - Part 2 of 3: *Nanostructures & Nanofillers*

Nanocomposites Roundtable Discussion

Thomas Köhler, Institut für Textiltechnik (ITA) der RWTH Aachen University

Technological and Economical Assessment of Nanoscale Fillers in Fibre Reinforced Thermoplastic Composites

For an optimal consolidation of fibre reinforced thermoplastic composites, the temperature distribution needs to be homogenous throughout the material. In the course of the BMBF-project "VIP Organo" the shortening effect of nanoscale fillers on the heating and cooling times of hybrid yarn-based thermoplastic composites is investigated at the Institute for Textile Technology, Aachen. The goal of this presentation is to give a first technical and economic assessment of this effect.

Jennifer Zhu, Ford Motor Co.

Bio-Based Polyamides Reinforced with Cellulose Nanofibers — Processing & Characterization

Bio-based polyamides, based on fully or partially renewable sources, are one of the most promising types of bioplastics due to their low density, good mechanical and thermal properties, and durability. These advantages make them key resins for automotive applications. In this study, cellulose nanofibers were successfully dispersed in bio-based polyamide matrices and the effect of loading levels on mechanical and thermal properties of the nanocomposites were investigated.

Nanocomposites - Part 3 of 3: *Nanosilica & Nano Trends*

Kumar Kunal, Evonik Corp.

Damage Tolerant Automotive Composites with Nanosilica Modifications

The poor toughness and fatigue performance and high cost of fiber reinforced composites presents significant challenges in their adoption in high-volume automotive structural parts. It has previously been shown that fatigue properties can be significantly improved by modification of the epoxy matrix resin with commercially available silica nanoparticles. This talk presents new results indicating that sufficient improvements are possible at much lower addition levels of silica nanoparticles, hence cost, if they are present at the fiber-matrix interface as part of the fiber sizing. This approach may open new avenues for cost-efficient manufacture of composite parts with outstanding service life even for high volume automobiles.

James Nelson, 3M

Nanosilica-Modified Epoxy Resins for Use in Lightweight Filament-Wound Drive Shaft Applications

This presentation explores and illustrates the enhanced properties of filament-wound carbon fiber tubes resulting from significantly increased matrix stiffness. Properties for a high-modulus nanosilica-modified matrix resin and unfilled control resin were measured. Filament winding was used to create carbon fiber composite tubes using the resins. The axial and hoop stiffness of the tubes were measured and compared to theory. Lightweight driveshaft structures are featured through the application of the nanosilica resin technology.

Mark Shaw, UltraTech International, Inc.

New Nanotechnology Initiatives in the Automotive Market

This talk will offer nanotechnologies that are commercialized or in the final stages before commercialization and are being used by or being evaluated by the auto industry. The topic will provide some insight into real-world nano-products and where they may have application within the automotive world. The result should be a quick overview of potentially game-changing products, showing the promise that we have all felt was possible in the nanotech world.

— IN DIAMOND BALLROOM —

Keynote 1

Carbon Fiber 2.0: Roadmap for Growth to 2020 and Beyond

Anthony Schiavo, Lux Research Inc.

Carbon fiber-reinforced plastics (CFRPs) combine high strength and light weight, making these materials attractive to many industries. However, due to high costs and other technical hurdles, thus far their use has been restricted to high-end niche applications. In order to forecast the near- and mid-term penetration of CFRPs into both major and emerging target industries, we built a detailed cost model based on current and near-term production technology, and an industry demand model based on the needs and adoption cycles of each application. We further analyzed key technological, market, and regulatory factors likely to affect the long-term growth of the carbon fiber market to create a road map to large-volume automotive applications.

Keynote 2

Institute for Advanced Composites Manufacturing Innovation (IACMI): A Disruptive Moment in Automotive History

Dr. Craig Blue, IACMI
Dr. Larry Drzal, *IACMI Director - Vehicles Technology Area* Michigan State University
Dr. Byron Pipes, *IACMI Director - Modeling and Simulation Technology Area* Pursue University
Brian Rice, *IACMI Director - Compressed Gas Storage Technology Area* University of Dayton Research Institute
Cliff Eberle, *IACMI Director - Materials and Process Technology Area* Oak Ridge National Laboratory

The need to reduce CO_2 emissions and improve fuel economy is providing an impetus for developments in lighter weight materials and alternative powertrains. In order to realize commercial application in mass-produced vehicles for advanced composites, costs and cycle times both need to be reduced. Further, end-to-end simulation tools need to be integrated, validated, and made widely available to speed development time and improve confidence in their ability to predict as-built performance. The recently launched Institute for Advanced Composites Manufacturing, Innovation (IACMI) is integrating materials, manufacturing, and simulation development concurrently, to aggressively meet the needs of the automotive industry for hybrid and composite-intensive vehicle structures. This presentation will lay out the organization of the institute and summarize work planned and already underway to make advanced composites more competitive.

THURSDAY, SEPTEMBER 10

— IN ONYX ROOM —

Opportunities & Challenges with Carbon Composites - Part 1 of 2: *New Prepreg Technologies*

Brian Gardner, Sigmatex Carbon Composite Solutions

The Lightweighting Excellence Program: High-Throughput Composites for Automotive Applications

Not available at press time.

Michael Karcher, Fraunhofer Institute for Chemical Technology

Evaluation of a New "InlinePrepreg" Process Approach to Established Processes for the Manufacturing of Structural Components out of Carbon Fibre Reinforced Plastics

The Fraunhofer ICT has been developing a new direct process approach — called the InlinePrepreg (InPreg) process — that eliminates the freezing, thawing, and storing steps of conventional prepreg manufacturing. A goal of the new process is to use high levels of automation, a press process, and less costly raw material such as 50K tow carbon fiber to lower overall costs and thereby enable large-series production of carbon fiber-reinforced plastic (CFRP) parts. This paper researches properties of the InlinePrepreg material and compares it to other established manufacturing processes for CFRP. An economic analysis is also conducted based on a fictional geometry.

Max Thouin, Mitsubishi Rayon Carbon Fiber & Composites

Automated Solution to High Volume Manufacturing Using Low-Cost PCM TowPrepreg

A new material format is being developed to overcome the limitations of traditional prepreg compression molding using automated fiber placement technologies. This new material allows significant cost reductions by eliminating the labor-intensive ply stacking operations and creating a fully automated production process. Most importantly, the localized deposition of fiber allows material waste to be cut from 30% down to approximately 3%. Calibrated width-towpreg offers a long needed alternative to traditional slit tape products. This presentation outlines a low-cost, fully automated solution suitable for series vehicle production.

Opportunities & Challenges with Carbon Composites - Part 2 of 2: Preforming, Woven Composites, & Lightweighting

Markus Thiessen, Compositence GmbH

Preforming 2.0 – Leap Innovations for Automotive by Compositence

Efficient preforming technology, combined with the ability to virtually design load-optimized parts are key drivers for cost-effective high-performance composite parts. The presentation will focus on a new preforming technology that allows tact times of 1-5 minutes, combined with low waste rates. Based on this technology, machines are now available for thermoset and thermoplastic applications as well as software for part design and production simulation. The presentation will focus on features of the technology, benefits for customers, scope of applications and provide application examples.

Jon Goering, Albany Engineered Composites

Application of 3D Woven Composites for Energy Absorption

Due the presence of through-thickness reinforcement, 3D woven composites have superior fracture toughness, fatigue life, and damage tolerance compared to conventional laminated composites. These materials also exhibit a progressive damage behavior that is more benign than the brittle failure typical of laminated composites, and have high specific energy absorption (SEA). These properties make 3D composites attractive for applications that require lightweighting without sacrificing crashworthiness. The goal of this study was to demonstrate this capability by comparing the energy absorption performance of 3D woven composites to that of laminated composites.

Brian Gardner, Sigmatex Carbon Composite Solutions

Recycled Carbon Thermoplastic for Automotive Lightweighting

SigmaRF is a recycled carbon fiber-reinforced thermoplastic fabric used to decrease production time of carbon composite part production while reducing overall vehicle weight. The carbon fibers used in the fabric are 100% recycled material utilizing trim wastestreams combined with a thermoplastic resin matrix. Fabric options vary from NCF multidirectional, woven, and spread fabrics.

Stephen Greydanus, HEXION Inc.

Advancements in Epoxy Technologies for Enabling Automotive Light-Weighting at High Build Rates

One of the major challenges for lightweight materials, especially carbon fiber-reinforced (CFRP) composites, is that they are typically higher cost than incumbent metal designs. As such, successful commercialization depends on combining "smart" composite designs with materials and processes that improve cycle time and reduce waste. This presentation discusses several advancements in epoxy technology that are enabling the production of lightweight composites at high build rates and contributing to overall lower costs.

— IN OPAL/GARNET ROOM —

Virtual Prototyping & Testing - Part 4 of 5: *Fiber Orientation*

Gregory Lambert, Virginia Polytechnic Institute and State University

Assessing the Performance of the Bead-Rod Model for Simulating Long Fiber Orientation in Basic Flows

This study considers the change in orientation of long glass fibers while undergoing shear and planar elongational deformation for the purpose of obtaining empirical parameters in an orientation evolution model. Planar elongation attains a high degree of flow-alignment much faster than shear, and hydrodynamic interactions appear to be much more important than direct fiber contacts when compared to shear.

Sebastian Goris, University of Wisconsin-Madison
2014-2015 ACCE scholarship winner

Fiber Orientation Measurements Using a Novel Image Processing Algorithm for Micro-Computed Tomography Scans

Measuring the microstructure of fiber-reinforced composites is an important tool for process simulations and quality assurance. A novel image processing algorithm has been developed that accurately quantifies the fiber-orientation distribution in fiber-reinforced composites for a wide range of different material combinations. The algorithm uses basic projection theory, which offers a concise and time-efficient method to analyze the fiber-orientation distribution from micro-computed tomography (μCT) scans.

Dhanendra Kumar Nagwanshi, SABIC

Plastic Hybrid Solutions in Truck Body-in-White Reinforcements and in Front Underrun Protection

With new and evolving safety regulations and stringent emission standards, automotive OEMs are exploring non-traditional lightweight multi-material solutions for structural components in vehicle body. This presentation covers thermoplastic-based metal and composite hybrid solutions for body-in-white (BIW) reinforcement for cabin safety regulations and front under-run protection devices for heavy motor vehicles as an alternative to incumbent solutions.

Virtual Prototyping & Testing - Part 5 of 5: *Anisotrophy Modeling*

Roger Assaker, e-Xstream engineering

Fiber Reinforced Plastic Durability: Nonlinear Multi-Scale Modeling for Structural Part Life Predictions

To tackle fiber-reinforced plastic durability, engineers look forward to accounting simultaneously for manufacturing process and nonlinear behavior. Both aspects are classically supported by multi-scale modeling, as demonstrated in this presentation. In particular, multi-scale modeling efficiently predicts different structural part lives for different fiber orientations or matrix nonlinear behaviors.

Doug Kenik, AutoDesk, Inc.

Bridging the Gap: As-Manufactured Structural Simulation of Injection Molded Plastics

This presentation discusses a new solution to seamlessly link the results of injection molding simulation with nonlinear material responses in structural finite-element analysis (FEA). The software features new methods to map data from manufacturing simulation to structural simulation, and a novel multi-scale progressive failure model for short fiber-filled plastics. Also described will be the theoretical foundations and capabilities of the software, in addition to validating the methodology against experimental data.

Roger Assaker, e-Xstream engineering

Anisotropic Damping Behavior of Reinforced Plastic Parts for NVH Simulations

A multi-scale finite-element method is proposed to numerically characterize the stiffness and damping behavior of a short glass fiber-reinforced material, including the dependencies to frequency, loading angle, fiber orientation, and fiber volume fraction. In a second step, the micromechanical material model enriched with these damping data is applied on a car's roof front beam on a typical frequency response finite-element analysis to study its effect on the predicted part's behavior.

Don Robbins, Autodesk, Inc.

Progressive Failure Simulation of As-Manufactured Short Fiber Filled Injection Molded Parts: Validation for Complex Geometries and Combined Load Conditions

This presentation discusses validation efforts for novel finite-element software that is used to seamlessly link the results of injection molding simulation to subsequent nonlinear structural-response simulation, thus allowing the user to simulate the structural response of the actual as-manufactured configuration of a short fiber-filled, injection molded plastic part. In particular, the presentation describes the process of characterizing short fiber-filled plastics using simple uniaxial tensile data, and the use of the characterized material model in simulating the failure of injection molded cruciform specimens that are loaded in biaxial tension. The theoretical foundations and software capabilities are discussed in a companion presentation.

Abstracts of Speaker Presentations 2015

— IN EMERALD/AMETHYST ROOM —

Advances in Thermoset Composites – Part 2 of 2:

Mike Gruskiewicz, A. Schulman - Engineered Composites

A New Approach to SMC Weight Reduction

This presentation examines a new approach to SMC weight reduction using a renewable resource filler to replace mineral filler in SMC. At a filler specific gravity of 1.1, compared to 2.7 for calcium carbonate, the filler achieves weight savings while offering the capability to sequester carbon and support the American farm economy. The filler is derived from soy hulls, a by-product of food and soy oil production, providing an outlet for a low value component as soy production continues to expand. A comparison of key performance attributes is presented relative to other SMC weight-reduction options.

Marcel Bruijn, Huntsman Polyurethanes

Latest Generation of Polyurethane Resins with Superior Process Control for Fast-Cycle Manufacturing of Structural Composites

The use of high performance composites is growing fast in many markets including automotive. Now novel polyurethane resins have been developed with unique reaction characteristics without compromising on the typical excellent mechanical properties. This latest generation of polyurethane resins has a significantly longer injectable time followed by a fast cure. This enables a more cost-effective, high-volume production of high-performance composite parts for the automotive market.

Sigrid ter Heide, HEXION Inc.

A Life Cycle Assessment-Based Comparison of Engineering Thermoset and Aluminum in an Automotive Under-the-Hood Application

The automotive industry is looking for options to reduce weight and increase engine efficiency to comply with new CO_2 emission and fuel-economy regulations. Substituting lighter weight materials may involve important tradeoffs such as those to the environment. Life cycle assessment (LCA) is a holistic approach to evaluating the potential environmental impacts of a product or process. An LCA incorporates all of the product manufacturing steps starting with raw material in-the-ground, on-the-hoof, or on-the-stalk, through the ultimate management of the product and its residuals at the end of their life. This presentation will discuss a comparative LCA on an automotive water pump housing manufactured with a thermoset composite resin relative to an alternative water pump housing manufactured from aluminum. The LCA results appear to support the conclusion that the lighter weight thermoset composite water pump housing has environmental benefits relative to the alternative aluminum water pump housing. LCA results can provide engineers and designers a (more) rational basis for comparing alternatives when used in conjunction with life cycle cost and product performance data.

Advances in Thermoplastic Composites

Yankai Yang, Hanwha Azdel Inc.

Development of Lightweight Reinforced Thermoplastic with Improved Stone Impingement Resistance for Automotive Underbody Application

This paper discusses the development of a lightweight reinforced thermoplastic (LWRT) product with improved stone impingement resistance for car underbody-shield application. The effect of the core formulations and skin materials on the stone impact performance was investigated. The study led to the design of an LWRT product with improved stone impingement property.

Eric Wollan, PlastiComp, Inc.

Hybrid Long Fiber Thermoplastic Composites: A Perfect Blend of Performance and Cost

A look at development trials for hybrid blends of long-glass and long-carbon fiber-reinforced thermoplastic composites was done. Can combinations of these fiber types bridge the performance gap between using them individually and lower the cost-to-entry barrier for adopting long-carbon fiber thermoplastic composite technology?

Cécile Demain, Solvay

Thermoplastic Composite Structural Part for Truck Market Application

This presentation describes the collaboration between members of a thermoplastic composite value chain — a European commercial truck OEM, Solvay (resin supplier), HBW-Gubesch (manufacturor), Sika (adhesive supplier), and Bolhoff (fastener supplier). The companies contributed on the successful development of a lightweight structural part for the truck market. The objective was to replace metal with thermoplastic composite while reducing mass 25%. To reach this target and fulfill OEM requirements, design and simulation were key and will be described.

Jacob Anderson, PPG Fiber Glass Reinforcement Technology Center

2015 Dr. Jackie Rehkopf Best Paper Award winner

Effect of Processing Technique on the Mechanical Performance of Glass Fiber Reinforced Thermoplastics

In the present work, thermoplastic bulk-molding compound (BMC) is investigated to determine its mechanical performance relative to granulated long-fiber thermoplastic (GLFT) and continuous fiber-reinforced thermoplastic tape (CFRT). This was achieved by using injection and compression molding to fabricate thermoplastic composite parts using GLFT, CFRT, and BMC. The BMC was shown to exhibit improvements in flex and impact performance of 100% and 20%, respectively, greater than the GLFT specimen.

Abstracts of Speaker Presentations 2015

— IN DIAMOND BALLROOM —

Keynote 3

Owning the Future: Sustainable Materials Research, Development & Implementation at Ford

Deborah Mielewski, *Senior Technical Leader of Sustainable Materials and Plastics Research*
Ford Motor Co.

The Ford biomaterials research program was initiated in 2001, and the group was the first to demonstrate soy-based foam that met all the requirements for automotive seating. Ford and Lear launched soy-based foam on the 2008 Mustang, and soy seat cushions and backs have now found their way into every Ford North American-built vehicle. Bio-based foams currently reduce greenhouse gas emissions by over 25-million pounds and reduce petroleum dependence by over 5-million pounds annually. The biomaterials research team continues to pioneer the development of sustainable plastic materials that meet stringent automotive requirements, including natural fiber-reinforced plastics and polymer resins made from renewable feedstocks. Ford currently has 8 renewable materials in production vehicles, making them a leader in automotive. Ford scientists are continuing to search for innovative and creative bio-technologies that can reduce our dependence on petroleum, create new markets for agricultural products and additional revenue streams for farmers, as well as reduce vehicle weight, which results in improved fuel efficiency and lower vehicle emissions. The past year, we have begun investigating cellulose nanofibers (CNF, CNC, cellulose filaments) because of their larger surface area, greater aspect ratio, and fascinating properties.

Keynote 4

Mass Production of CFRP in Automotive Applications – Potential and Challenges in Implementing Local Reinforcements

Stefan Stanglmaier, *Technologieentwicklung CFK Material- und Prozessabsicherung*
BMW Group

In 2013 the BMW Group put the fully electric *BMW i3* and in 2014 the hybrid super sports car, the *BMW i8* on the market. Both cars have a two-piece chassis, in which the lower (Drive-Module plastic) primarily consists of aluminium and the passenger cell (Life-Module) is constructed from carbon fibre-reinforced plastic (CFRP). BMW successfully implemented CFRP fabrication processes for the production of the Life-Module components of both cars with an automation level and cycle times suitable for mass production. From the experience gained from the production of structural CFRP components, the BMW Group applied different promising approaches on how to further improve the methods and techniques of current production systems. Based on this knowledge, the future focus of the advancements in the CFRP sector at the BMW Group will be on design and production of parts with maximum exploitation of the material's mechanical potential, minimal material input, optimized weight, and with equivalent costs compared to other materials. This presentation will first look at the current production processes for the *BMW i3* and *BMW i8* as starting points to advance the current CFRP production systems, and then provide perspective on future development projects. As an example of these projects, several results will be shown from one venture enhancing the RTM (resin transfer molding) and Wetpressing processes for the production of local reinforced CFRP parts with the required properties at the process and component level.

THURSDAY, SEPTEMBER 10

— IN ONYX ROOM —

Enabling Technologies - Part 1 of 3: *New Manufacturing Strategies*

Chuck Buckley, Dassault Systèmes

Business Intelligence to Help Define Composite Processes Measurements and Production Predictive Analytics

Composite manufacturing is a complex process that continues to test the boundaries of a repeatable and reproducible production process. This presentation will focus on the use of a new innovation that applies patented predictive analysis tools, which have been proven to significantly reduce the costs of composite component scrap, rework, and repair. While analyzing the complex process, this approach helps manufacturers to define those critical characteristics that should be measured and have the greatest level of impact on the process outcome. Production rules are defined and able to be institutionalized so that the factory floor can be advised, in a predictive manner, of pending production issues.

Burak Uzman, Coriolis Composites SAS

Automated Manufacturing for Mass Production and Low-Cost Materials

The next challenges for composites manufacturing will be to address high-volume production and very-complex parts, especially for the automotive industry. Both machine manufacturers and simulation software editors must develop breakthrough technology: low-cost materials, scrap and mass optimization, high-volume layup machines, and accurate numerical simulation of thermo-forming process. Developments in those domains, using a strong know-how of automated fiber placement processes and aerospace industry projects, will be shown. Next a technology proposal is described, including machine concept, materials to be processed, productivity and process issues, like material capability to be processed at high speed, or preform optimization regarding impregnation or forming issues. Projects done with automotive OEM and tier 1 will conclude the presentation to illustrate the technology developments.

Abstracts of Speaker Presentations 2015

Andrew Rypkema, Pinette Emidecau Industries

QSP: A Breakthrough Approach for Automating High Performance Thermoplastic Composites

The quilted stratum process (QSP) is a breakthrough approach for automating the manufacture of high-performance thermoplastic composites. QSP allows for use of a wide variety of materials in the design and production of a thermoplastic composite parts. With this new robust manufacturing process QSP attains the desirable goals of using high-performance, continuous-fiber-reinforced composite materials, low cost, and short cycle time simultaneously.

— IN OPAL/GARNET ROOM —

Sustainable Composites - Part 1 of 2: *Reinforcements*

Amy Langhorst, Ford Motor Co.
2015 Dr. Jackie Rehkopf Best Paper Award winner

Selective Dispersion and Compatibilizing Effect of Cellulose Filler in Recycled PA6 / PP Blends

The environmental impact of automobiles can be reduced by using combinations of recycled polymers and natural reinforcements to replace traditionally unfilled, glass-filled, and talc-filled polymeric components. Composites containing recycled polypropylene, recycled polyamide 6, and cellulose were produced using a twin-screw extruder and injection molding. The resulting properties were investigated on a microscopic (scanning electron microscope) and macroscopic (mechanical and thermal properties) scale.

Niloofar Yousefi Shivyari, University of Maine

All-Renewable Paper Nano-Laminates for Automotive Applications

This research aims at producing paper nano-laminates using relatively new and sustainable cellulose nanofibrils (CNF), which act as both the binder and the reinforcing agent for layers of paper. Upon optimization, the nano-laminates could exhibit high mechanical properties. They can have various thicknesses, are fully renewable, biodegradable, and lightweight, and also are hydro-formable both during and after forming.

William Jordan, Baylor University

Improving the Properties of Banana Pseudo-Stem Fiber LDPE Composites by Chemically and Thermally Treating the Fibers

This project used fibers from the pseudo-stem of the banana plant. One of the problems with using plant fibers in a polymer matrix is the fiber's natural tendency to absorb moisture, which leads to a weakening of the overall strength of the fiber, as well as problems with interfacial bonding between fiber and matrix. This presentation examines ways of mitigating this through chemical treatments that serve to lower the hydrophilicity and/or increase surface roughness to improve interfacial bonding.

— IN EMERALD/AMETHYST ROOM —

Advances in Reinforcement Technologies

Hendrik Mainka, Volkswagen AG

Raman and X-ray Photoelectron Spectroscopy: Useful Tools for the Chemical Characterization of the Conversion Process of Lignin to Carbon Fiber

Today's limitation for the use of carbon fiber is the cost of the conventional carbon fiber precursor, poly-acrylic-nitrile (PAN). Around 50% of the cost of a conventional carbon fiber belongs to the PAN precursor. Lignin as a precursor for carbon fiber production can realize enormous cost savings. For qualifying lignin-based carbon fiber for automotive mass production, a detailed characterization of this new material is necessary. Therefore Raman and X-ray photoelectron spectroscopy are used, details of which are covered in this presentation.

Christopher Pastore, Philadelphia University
2015 Dr. Jackie Rehkopf Best Paper Award winner

Lightweighting Composites Through Selective Fiber Placement

The underlying idea is to use the more expensive carbon fiber only where needed through the use of a gradient hybrid material that incorporates glass everywhere else. The goal is a process that allows automation while optimizing weight and cost for a given structural element. Through a combination of theoretical and experimental evaluations, a methodology for evaluating the weight-cost efficiency of chopped fiber composites was developed and confirmed experimentally.

David Jack, Baylor University

The Impact of Nozzle Shape & Convergence Flow on the Extrudate Fiber Orientation & Subsequent Stiffness in Fused Deposition Modeling

Through the addition of discontinuous fiber reinforcements, such as chopped fiberglass or carbon fibers, the potential for structural components from the fused deposition modeling (FDM) process may become possible once the impact of the nozzle design on the resulting processed part stiffness is understood. This work presents a study, using physics-based modeling, of the impact the nozzle shape and convergence zone have on the extrudate's underlying fiber microstructure and the resulting spatially varying stiffness. Results indicate the nozzle geometry causes significant fiber alignment, but this alignment is reduced measurably by the extrudate swell prior to deposition thus reducing the resulting part stiffness.

— IN DIAMOND BALLROOM —

Panel Discussion

Carbon Steel to Carbon Composites – Can the Existing Automotive Infrastructure be Leveraged to meet Lightweighting Targets?

Jan-Anders Månson, *Moderator*
Laboratory of Polymer and Composite Materials (LTC), Ecole Polytechnique Federale de Lausanne (EPFL),
Panelists: Glade Gunther, Cytec Industries Inc.;
Paul Krajewski, General Motors Co.;
Peter Ulintz, Precision Metalforming Association;
Rainer Kossak, Ph.D., Novelis Inc.;
Markus Geier, Schuler Inc.;
Gary Maddocks, Zapp Tooling Alloys Inc.

A major barrier to the penetration of high-performance composites in automotive structures is the large investment in legacy processes, such as sheet-metal stamping, and the lack of a large supply chain for composites. Recent developments in "stamp forming" of both thermoset and thermoplastic continuous composite sheet materials offers intriguing possibilities to convert some existing assets, such as steel presses, to forming composite materials. How practical is this approach and what considerations must be taken into account in order to prove that it could work? This panel will explore these and other questions representatives from traditional press and tool-&-die companies, along with composite material suppliers, Tier 1 molders, and OEMs participating in the discussion.

FRIDAY, SEPTEMBER 11

— IN CRYSTAL/SAPPHIRE/RUBY ROOM —

Enabling Technologies - Part 2 of 3: *Advances in RTM Technology*

Tobias Jansen, Hennecke GmbH
The HP-RTM Technology – Actual Status and New Developments

Due to increasing requirements for efficiency and ecology, interest in lightweight solutions for the automotive industry has been growing. The focus is especially on one process: resin transfer moulding (RTM), which is the topic of this presentation.

Philipp Rosenberg, Fraunhofer Institute for Chemical Technology
Characterization of Epoxy and Polyurethane Resin Systems for Manufacturing of High-Performance Composites in High-Pressure RTM Process

The high-pressure RTM (HP-RTM) process is a manufacturing technology capable for high-volume production of fiber-reinforced plastics (FRPs) in the automotive industry. The presented study characterizes 2 matrix materials, epoxy and polyurethane resins, adapted for use in HP-RTM equipment for their process-specific behavior and mechanical properties. The results demonstrate potentials of different matrix materials in the HP-RTM process combined with basic mechanical properties in combination with carbon fiber reinforcements.

Ian Swentek, Fraunhofer Project Centre for Composite Research at the Western University
Impact of HP-RTM Process Parameters on Mechanical Properties using Epoxy and Polyurethane

High-pressure resin transfer molding is used to process glass and carbon fiber composites with epoxy and polyurethane. Three process parameters are varied and their impact on mechanical properties is measured. The results document the critical process parameters and build upon the HP-RTM best practices as previously reported.

Erich Fries, KraussMaffei Technologies GmbH
Light Weight Technology — New Approach Thermoplastic RTM / Surface RTM and Fiber Form Technology

For many years, KraussMaffei has been working with widely varying processes for manufacturing parts made of fiber-reinforced plastic (FRP). These processes have traditionally evolved from injection molding technology and reaction technology (polyurethane/epoxy). The latest demands in the markets are for highly automated processes like Fiber Form and the use of less costly raw materials e.g. polyamide 6 (T-RTM).

Enabling Technologies - Part 3 of 3: *NDT, Direct Fiber Feeding, & Hybrid Vehicles*

Jan Olav Endrerud, DolphiTech AS
Non-Expert NDT Solution for Composite Materials in the Automotive Industry

Composite materials are being used in the automotive industry at an increasing pace. As these materials are being used in primary structures, new inspection methods are needed both in manufacturing and during the life time of the vehicle. Visual inspections may be sufficient on metallic structures, but cannot be trusted on composite parts. Limitations on visual inspections are discussed, and methods for a scalable non-destructive testing (NDT) solution for structural composite parts are proposed.

Abstracts of Speaker Presentations 2015

Martino Lamacchia, Cannon USA

An Innovative Solution for the Production of PUR-Based Reinforced Composite Parts for the Latest Hybrid Vehicles

The presentation covers an innovative approach to the manufacturing of a glass-reinforced polyurethane-based transverse leaf spring for the rear multilink suspension of the new *Volvo XC 90* SUV manufactured by Benteler-SGL, on a Benteler Machinenbau line with Cannon equipment. Particular focus is given on how the HP-RTM process made possible the mass production of several-hundred thousands of these component annually in an automated and repeatable way.

Ingo Valentin, Valentin Technologies, LLC

Cost Efficient Composite Platform with Integrated Energy Storage for a Hydraulic Hybrid

The Hydraulic Hybrid is based on a composite platform with an integrated hydrostatic drivetrain and accumulator. The energy-storing and load-carrying accumulator results in ultra-low weights for the platform and a simplified car body. The improvements in weight and efficiency reduce both fuel consumption (1.22 L/100 km / 193 MPG) and CO_2 emissions (32.4 g/100 km) dramatically.

— IN OPAL/GARNET ROOM —

Sustainable Composites - Part 2 of 2: *Polymers & Trends*

Sustainable Composites Roundtable Discussion

Henning Karbstein, BASF Corp.

Acrodur® Natural Fiber Composites: New Opportunities with Thermoplastic Binder

Natural fiber composites with non-woven materials and fibers from kenaf, hemp, or flax are well known in the automotive industry as a smart, lightweight alternative for interior panels. BASF's water-based thermoset binder technology is an alternative to thermoplastic forming with polypropylene prepregs. In 2015, an innovative, new water-based binder was developed that also allows for thermoplastic processing, similar to polypropylene, but achieves higher mechanical properties. This presentation discusses processing options and mechanical performance data as a direct comparison to incumbent materials.

Andrea Birch, Ford Motor Co. / University of Waterloo

Development of Cost Effective and Sustainable Polyamide Blends for Automotive Applications

Recent years have witnessed an enormous expansion of research and technology developments especially in the automotive industry on bio-based polyamides. In spite of the increasing scientific and industrial activity, there is still one major problem associated with bio-based polyamides in general: their relatively high cost vs. their petrochemical homologues. In this research, we report on a cost-effective and sustainable approach for the development of lightweight and high strength and modulus materials for automotive applications using composites based on a bio-based polyamide (PA) 6/10 and recycled PA 6 (RPA 6) blend with cellulose fibers. These materials not only provide good mechanical and thermal properties but are lighter than glass-reinforced composites for the automotive industry.

Atul Bali, Competitive Green Technologies

Light-Weighting Opportunities using Bio-Materials in Automotive Applications

A very significant opportunity exists in automotive applications — particularly for injection molded parts — to use natural fibers like perennial grasses as fillers that have remarkable reinforcement properties and can be, through creative chemical bonding, compatibilized with polymer matrices to create strong bonding. Also key is development of a drop-in substitute bio-resin that is price-performance competitive and above all process compatible with prevailing injection molding tools. When combined with thin-walling techniques, this can provide an opportunity for a 'running change' on a given platform and offer mass savings of 10-20% at no cost or process penalty and without sacrificing performance.

Bonding, Joining & Finishing

Michael Day, American Chemistry Council - Plastics Division
Mahmoodul Haq, Michigan State University

Efficient Assembly & Joining: Reversible Bonded Joints Using Nano-Ferromagnetic Particles

CAR and MSU/CVRC have partnered to investigate an innovative joining technique along with its cost-benefit analysis. The MSU/CVRC research explores reversible bonding using nano-ferromagnetic particles in thermoplastic adhesives. CAR's business case study deals with a cost-benefit analysis model for the joining technology benchmarked by the conventional steel joining.

Ryan Schuelke, Enercon Industries

Implementing Plasma & Flame Surface Treating Technologies to Improve Adhesion with Composite Materials

In-line surface treatment technologies are used to clean, micro-etch, and functionalize surfaces to promote adhesion, improve quality, and increase productivity. Learn how atmospheric plasma and flame surface treating technologies effectively improve the surface properties of composite materials for bonding with inks, adhesives, and coatings. And find out how they can be efficiently integrated into production lines to maximize output.

Andy Stecher, Plasmatreat USA, Inc.

Surface Treatments for Better Performance and Automation in Composite Bonding and Manufacturing

Atmospheric plasma is a touchless and workplace-safe alternative to traditional wet chemical and/or mechanical surface preparation methods before CFRP part are joined or bonded to dissimilar substrates. Atmospheric plasma enables high speed and fully automated surface conditioning for large areas. Plasma coating of molds also can replace conventional mold release chemistry with a non-transferable plasma deposited release film.

— IN EMERALD/AMETHYST ROOM —

Tutorials

Louis Dorworth, Abaris Training Resources

Adhesive Bonding of CFRP Composites: Practices and Principles

This interactive tutorial provides a comprehensive look at common industry practices and the basic scientific principles involved in adhesive bonding of CFRP composite materials. This presentation will focus on universal methods and techniques used to achieve durable and consistent adhesive bonds in both manufacturing and repair of these structures. The talk includes an overview of modern surface analysis equipment and a primer on testing methods and failure modes.

Karen Stoeffler, National Research Council Canada (NRCC)

Biomaterials for Automotive Applications

This 60-minute tutorial will cover the basics in designing sustainable plastic and composite materials for automotive applications to replace conventional petroleum-based materials. The emphasis will be on incorporation of polymers and reinforcements (particles, short and long fibers) sourced from renewable, non-edible resources in automotive components. Challenges related to the formulation, fabrication, properties, and cost of those materials will be discussed. Specific issues such as odor emissions, moisture sensitivity, and durability also will be covered.

— IN DIAMOND BALLROOM —

Keynote 5

Zenos E10: A Platform for Novel Lightweight Automotive Composite Structural Design

Antony Dodworth, *Chief Technology & Manufacturing Officer,* Brite Lite Structures

The *Zenos E10* is a new English sports car designed as a modern take on the famous *Lotus 7*. The vehicle features low-cost composite chassis structure that functions as both interior and exterior, requires minimal body work, and is self-jigging and can be slotted together. The structure uses a unique new honeycomb-sandwich composite that meets or exceeds the compression, stiffness, and torsional rigidity required for the vehicle's chassis. Because of the nature of the sandwich structure, it enables the use of complex, deep-draw designs, which are not otherwise possible without preforming and which enable significant reductions in part count and bill-of-materials vs. structures in steel, aluminum, or monolithic carbon composite. This presentation will detail development of the novel structural composite made with thermoplastic honeycomb cores and polyurethane chemistry including recycled carbon fiber and polycarbonate. Complete curing and fabrication cycle time is under 10 minutes using patent-pending methods. Parts can be produced in a low-cost manufacturing cell capable of producing up to 15,000 parts/year using off-the-shelf presses, and spray and robotic equipment.

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