

2 n d A n n u a l

Automotive Composites

C O N F E R E N C E



SOCIETY OF PLASTICS ENGINEERS
Automotive & Composites Divisions

Composites

Global Technologies
for Better Vehicles

September 12-13, 2002

MSU Management Education Center
811 W. Square Lake Road Troy, MI 48084, USA

Presented by

Society of Plastics Engineers

Automotive & Composites Divisions

W e l c o m e



The Automotive and Composites Divisions of the Society of Plastics Engineers welcome participants to the 2nd Annual Automotive Composites Conference. Many exciting new automotive composite applications have come to market within the past few years. A wide range of materials and process technologies have been utilized to commercialize products such as the:

- V70[®] gear box support bracket from Volvo[®]
- A2[®] structural front-end module carrier from Audi[®]
- Silverado[®] pickup truck box from General Motors[®]
- Vanquish[®] side structural frame from Aston Martin[®]
- Thunderbird[®] exterior body panels from Ford Motor Company[®]

These applications came to fruition only through a multidisciplinary, time-consuming effort from material and equipment suppliers, molders and processors, and the OEM engineering community. Looking at these examples, it is obvious that automotive composite materials development is a global endeavor, hence, our “*Global Technologies for Better Vehicles*” theme of this year’s conference.

Engineers and business managers in the automotive composites community are well aware of the potential benefits composite materials can bring through reduced weight, improved safety, and parts consolidation. However, many barriers to market entry remain, including improving surface quality, understanding crash energy management, and developing part joining methods. As composites are applied to ever larger, more complex structural parts, expectations in material and process performance are increasing. Part production is becoming more demanding in terms of cost and productivity, and the composites community faces more competition from alternate materials such as aluminum, steel, and magnesium.

SPE has organized this conference to continue a path of learning for all participants about practical solutions to composite materials development and use. Sessions have been planned on *New Materials & Processes*, *Enabling Technologies*, *Bonding, Painting & Decorating*, and *Truck & Transport Applications*. Key new growth areas of *Biocomposites* and *Fuel Cell & Hybrid Powertrain Applications* are also included in the technical program. VIP speakers and a VIP Panel discussion will enumerate both past successes and future directions in automotive composites.

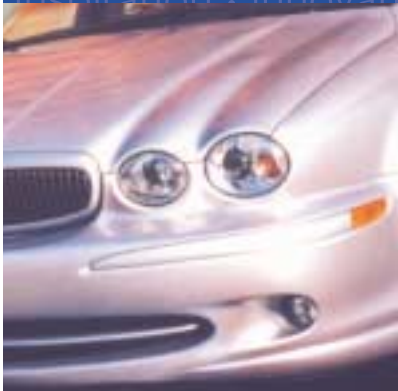
SPE is grateful to all sponsors, exhibitors, and volunteers for providing the tremendous support required to make this conference a success. And SPE and the conference organizing committee thank you for attending.

Sincerely,

Michael Connolly, Ph. D.
Chair – 2002 SPE Automotive Composites Conference

CONFERENCE ORGANIZERS

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Fuel Cell & Powertrain

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Pat Levine

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pat_levine@plastics.org

248-244-8993

- = Auditorium
- = Amplitheatre 101
- = Amplitheatre 102

FINAL conference AGENDA

T H U R S D A Y

	Introduction		
8:30-9:00	New Composite Materials & Processes <i>Nippani Rao</i> A New Self-Reinforced Polypropylene Composite	Composites for Fuel Cells & Hybrid Powertrain <i>Wil Connor</i> Electrochemical and Stack Evaluation of Composite Bipolar Plate Materials	
9:00-9:25			
9:25-9:50	Alternatives in Fiber Reinforced Thermoplastics for Automotive Applications	Development of an All-Composite Tank for High Pressure Hydrogen Storage	
9:50-10:20	Coffee Break & Exhibits		
10:20-10:45	Application of Carbon Fiber in SMC in the 2003 Viper Convertible	Current Technologies and Market Position of Thermoset Bi-polar Plates in the U.S.	
10:45-11:10	Developments in Thermoplastic Door Modules	Polymeric Composite Bipolar Plates for Vehicle Applications	
11:10-12:15	Lunch & Exhibits-Dining Room		
12:15-1:00	Keynote Speaker-Auditorium-Dave Hill, GMNA Vehicle Line Executive & Vehicle Chief Engineer, "Composites in Performance Cars"		
1:00-1:25	New Composite Materials & Processes <i>Suresh Shah</i> Roll Forming of Advanced Thermoplastic Composite Materials	Composites for Fuel Cells & Hybrid Powertrain <i>Wil Connor</i> Engineered Structural Composite (ESC) Materials in Stiffness-Critical Fuel Cell Applications	Painting & Decorating Composites Panel <i>David Reed-Organizer</i> (No Papers) Composites Finishing - The SMC Challenge - Dave Mattis Moderator
1:25-1:50	New Developments in Co-Rotating Twin-Screw Extrusion for Production of Long Glass Fiber Composites	A Novel Composite Plate for PEM Fuel Cells	Getting SMC Right - Jim Haverland, GM Director Polymers and Painted/Plastics
1:50-2:10	Coffee Break & Exhibits		
2:10-2:35	Best Practices on Processing and Handling of Long Fiber Reinforced Thermoplastics	Bipolar Plates for Fuel Cell Applications	3C's Program to Make SMC Paint Like Steel - Nippani Rao, DaimlerChrysler
2:35-3:00	Injection Molding Compounds: A Revolution in Injection Molding	Fuel Cell Applications Update	Experience and Needs Painting SMC - Ron Kettlehut / Frank Migda, Ford
3:00-5:00	Government Policy Panel-Moderator: Suzanne M. Cole, Chairman, SPE Automotive Division and President Cole & Associates, Inc.		Toughened Class 'A' SMC - Ken Rusch, Consultant
3:00-3:40	William G. Rosenberg, President & CEO MBDA; L. Brooks Patterson, Oakland County Executive; Doug Rothwell, President & CEO Michigan Economic Development Corporation		Making SMC Transparent [to the Paint System] - Jeff Robins, Meridian
5:00-6:30	Cocktails & Exhibits		
			Improving SMC for Paintability - Enamul Haque, Owens Corning Automotive

Rooms For Sessions:

- = Auditorium
- = Amphitheatre 101
- = Amphitheatre 102

FINAL conference AGENDA

F R I D A Y

8:30-8:55	<p>New Composite Materials & Processes <i>Jay Raisoni</i></p> <p>Economical Production Technology for Low & High Volume 3-D TPC Parts</p>	<p>Biocomposites <i>Larry Drzal</i></p> <p>Injection Moldable Long Natural Fiber Reinforced Polypropylene for Automotive Applications</p>	<p>Enabling Technologies for Composites <i>Dan Buckley</i></p> <p>Using Computer Aided Engineering to Design Better Thermoset Composite Parts</p>
8:55-9:20	<p>Multiwall Carbon Nanotubes</p>	<p>Soy Biobased Materials for Automotive Applications</p>	<p>Analysis of Resin Flow Under Flexible Cover in Vacuum-Assisted Resin Infusion</p>
9:20-9:45	<p>Tough, Low Mass Conductive Class 'A' SMC</p>	<p>Automotive Composite Parts Made with Natural Fibers and Honeycomb Cores</p>	<p>Process Simulation of Thermoplastic Composites in Compression Molding</p>
9:45-10:15	Coffee Break & Exhibits		
10:15-10:40	<p>Low Density Thermoplastic Composites for In-Mold Decoration and Low Pressure Molding</p>	<p>Biobased Polyurethanes from Plant Oil-Based Polyols: Physico-Mechanical Properties Evaluations</p>	<p>Influence of Consolidation and Forming Parameters in the Molding of Continuous Fiber Reinforced Thermoplastic Composites</p>
10:40-11:05	<p>Graphite Nanoplatelets as Reinforcements for Polymers: Structural, Electrical and Thermal Properties</p>	<p>Growing and Processing Natural Renewable BAST Fibers for Natural Fiber Composites</p>	<p>FiberSIM: Advanced CAD Software for Composite Engineering, from Racing to Production Automotive</p>
11:05-11:30	<p>No Postcure RRIM for Automotive Exteriors</p>	<p>Engineered BioPlastic Starch Foams – Potential in Automotive Application</p>	<p>Processes and Applications Using Six-Axis Robots to Perform Flexible Trimming on Thermoplastic Parts</p>
11:30-1:00	Lunch & Exhibits		
1:00-1:25	<p>New Composite Materials & Processes <i>Al Murray</i></p> <p>Electron Beam Processing for Automotive Composites Applications</p>	<p>Bonding Composites <i>Fred Deans</i></p> <p>Structural Adhesive Systems Overview</p>	<p>Enabling Technologies for Composites <i>Dan Buckley</i></p> <p>Coupled Pre-Forming/Injection Simulations Of Liquid Composite Molding Processes</p>
1:25-1:50	<p>Sandwich Construction for Surface Transportation</p>	<p>Ultraviolet Light as an Effective Cleaning, and Surface Preparation Process for Adhesive Bonding and Painting of Polymers, Composites, and Metals</p>	<p>Crash Simulation for High Performance Composite and Aluminum Automotive Structures</p>
1:50-2:10	Coffee Break & Exhibits		
2:10-2:35	<p>Advanced Technology of LFT-D Parts Production</p>	<p>Bonding Composites <i>Fred Deans</i> The Bonding of Engineered Structures in the 21st Century A New Class of Structural Adhesives</p>	
2:35-3:00	<p>Truck & Transport <i>Al Murray</i> Designing for Durability Using an E-Glass Reinforced SRIM Urethane Composite</p>	<p>Enhanced Bonding of Polypropylene to Polypropylene and other Materials with Novel Thermoplastic Heat Activated Adhesives</p>	
3:00-3:25	<p>Development of a Long Fiber Reinforced Composite Seat Structure for Mass Transit Applications</p>	<p>Fiber-Filled Materials and New Flexible Design Methodology for Hybrid Front-End Carriers</p>	
3:25-4:00	Closing Remarks		



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conference PRESENTATIONS

New Composite Materials & Processes

A New Self-Reinforced Polypropylene Composite

- Renita S. Jones and Derek E. Riley, C.Eng., BP Curv™ Composites

Mechanical properties and automotive applications are discussed for a novel 100% PP 'self-reinforced', thermoformable composite.

Roll Forming of Advanced Thermoplastic Composite Materials

- R. J. Dykes, T. B. Logue, Pyramid Moldings, Inc.

This paper provides a general overview of the roll forming process as it relates to forming thermoplastic composite materials.

Injection Molding Compounders: A Revolution in Injection Molding

- Matthias Sieverding, Krauss Maffei

One Twin-Screw Extruder + One Injection Molding Machine = One Injection Molding Compounder

Graphite Nanoplatelets as Reinforcements for Polymers: Structural, Electrical, and Thermal Properties

- H. Fukushima and L.T. Drzal, Department of Chemical Engineering and Materials Science, Composite Materials and Structures Center, Michigan State University

This paper will present new data on graphite nanoplatelets that can be used as a structural, thermally, and electrically conductive alternative to clay nanoplatelets and are cost competitive.

Economical Production Technology for Low & High Volume 3-D TPC Parts

- Tyler Johnson, Vasilius Brachos and Vinny Borbone

How new technology balances the economical relationship between capital equipment costs, tooling costs, & production volumes.

Electron Beam Processing for Automotive Composites Applications

- Song Cheng and David R. Kerluke, IBA, Advanced Materials Division

This paper presents an overview of potential uses of electron beam technology for automotive applications, including curing of SMC and RTM / VARTM components, filament wound components, large body/chassis components, adhesive bonding of composite components, composite resins, and thermoplastic composites, as well as some important non-composite automotive applications.

Tough, Low Mass Conductive Class 'A' SMC

- Bud Leach, Ashland Specialty Chemical Company, Composite Polymers Division

A class "A" tough, low mass, conductive system which is designed to be formulated into sheet molding composite (SMC) for external automotive body panel applications is discussed.

Developments in Thermoplastic Door Modules

- Maria Cilberti, Owens Corning Automotive and Warren Schijve DSM Research

The use of door modules as a pre-assembled functional unit inside a car door is discussed along with reasons why a door module should be used, and why a long glass fiber reinforced PP material is a good choice.

Application of Carbon Fiber in SMC in the 2003 Viper Convertible

- Mark Bruderick, Douglas Denton, and Michael Shinedling, DaimlerChrysler Corporation and Michael Kiesel, Quantum Composites, Inc.

The all-new 2003 Dodge Viper takes advantage of innovative applications of carbon fiber composites for large body structures and reinforcements.

Alternatives in Fiber Reinforced Thermoplastics for Automotive Applications

- Nathan Johnson, Hexcel Composites

Discussion of long and continuous fiber reinforced thermoplastics including a variety of higher performing resins with fiberglass and carbon fiber.

Multiwall Carbon Nanotubes

- Pat Collins, Hyperion Catalysis International

Multiwall carbon nanotubes are a very small, high aspect ratio conductive additive for plastics; they enable low loadings that preserve more of the resin's toughness.

Advanced Materials for a Smart Lightweight Design

- H. Dittmar, K. Brentrup, T. Hofmann, W. Maier, D. LoPresti, D. Schönberger, R. Törnqvist, Quadrant Plastic Composites

Stiff and lightweight parts with good acoustic performance are molded from self-expanding thermoplastic composites by tailored consolidation using a low pressure molding process with integrated in-mold decoration.

Processes and Applications Using Six-Axis Robots to Perform Flexible Trimming on Thermoplastic Parts

- Doug Cicchini - Robotic Production Technology

The presentation will discuss using six-axis robots to perform flexible trimming on plastic thermoformed parts utilizing processes such as laser, water jet cutting, router trimming, and knife deflashing.

Sandwich Construction for Surface Transportation

- Alejandro (Alex) Gutierrez, DIAB Inc.

In this paper, an overview of sandwich construction, together with the general application of sandwich composites for surface transportation will be explored. This will include successful cases in the bus, rail, truck, and automotive industries where the manufacturer attained significant gains by applying this technology.

conference PRESENTATIONS

Advanced Technology of LFT-D Part Production: A Cost Effective Part Production for Fiber Reinforced Parts

☛ Manfred Bruemmer, General Manager, Dieffenbacher Inc.
The paper contains the function of the process as well as the output capacity as related to various examples for fiber reinforced plastics parts. It also describes the cost effectiveness over various fiber reinforced technologies.

Best Practices on Processing and Handling of Long Fiber Reinforced Thermoplastics

☛ Rick Gregory, LNP Engineering Plastics, Inc.
The best practices in the area of processing and handling of long fiber reinforced thermoplastics will be presented with the ultimate goal of educating the automotive composites molding community on proper molding equipment and processing parameters and best practices for LFRT material handling in manufacturing operations ranging from small scale to large volume / bulk handling environments.

Enabling Technologies for Composites

Using Computer-Aided Engineering to Design Better Thermoset Composite Parts

☛ Bruce Davis, Paul Gramann and Antoine Rios
The Madison Group
This paper focuses on the effects of fiber orientation anisotropies on the structural performance of thermoset composite parts.

Influence of Consolidation and Forming Parameters in the Molding of Continuous Fiber Reinforced Thermoplastic Composites

☛ Gilbert Lebrun, Johanne Denault and Martin N. Bureau, CNC
University of Montreal Engineering Technology Associates
The influence of laminate consolidation parameters on the microstructure and mechanical properties of the laminate and the deformation mechanisms induced in the laminate in typical forming conditions are presented and discussed in regard to their influence on the physical and aesthetic properties of continuous fiber reinforced thermoplastic (CFRTP) composite parts.

Coupled Pre-Forming / Injection Simulations of Liquid Composite Molding Processes

☛ P. de Luca, Y. Benoit, ESI Software (ESI Group),
O. Morisot, ESI North America (ESI Group)
This paper gives a state of the art industrial numerical simulation (as opposed to academic simulation) in domains that all together encompass the whole life of a composite part: thermoforming, liquid composite molding, structural analysis and crashworthiness. Examples are reported in all of these fields.

New Developments in Co-Rotating Twin-Screw Extrusion for Production of Long Glass Fiber Composites

☛ Daniel Schwendemann and Ralph Cutillo
Coperion Werner & Pfleiderer
Advancements in equipment for the production of long glass fibers for in-line compounding, couple the twin screw extruder with compression molding.

FiberSIM: Advanced CAD Software for Composite Engineering, from Racing to Production Automotive

☛ Dr. Olivier Guillermin, VISTAGY, Inc.
By using the CAD integrated FiberSIM software for composite design and manufacturing, automotive engineers can readily assess part producibility and performance, and reduce the cost and time required to develop complex composite parts and assemblies.

Process Simulation of Thermoplastic Composites in Compression Molding

☛ Uday Vaidya, Department of Materials Science & Engineering,
The University of Alabama at Birmingham, and Klaus Gleich,
Southern Research Institute
This study deals with process simulation of the extrusion-compression molding of long fiber polypropylene thermoplastics for transportation relevant structural components.

Analysis of Resin Flow Under Flexible Cover in Vacuum Assisted Resin Infusion

☛ Laurent Joubaud, François Trochu, Jérôme Le Corvec,
Department of Mechanical Engineering, Applied Research
Centre on Polymers (CRASP), Ecole Polytechnique, and
Jérôme Le Corvec, Kaizen Technologies
Vacuum Assisted Resin Infusion (VARI) can be correctly predicted, as verified here for an ambulance roof, by Resin Transfer Molding (RTM) simulation software if the "flexible" permeability of the fibrous reinforcement is properly measured and used in the analysis.

Crash Simulation for High Performance Composite and Aluminum Automotive Structures

☛ Akbar Farahani, Ph.D., Engineering Technology
Associates, Inc.
A case study will be discussed where a vehicle body structure is developed under a virtual environment using composite body panel and aluminum space frame structure, using nonlinear, dynamic finite element analysis. The study will also discuss how the initial design was modified to improve the performance, resulting in a vehicle structure which showed an excellent performance in meeting all FMVSS and ECE regulations.

No Postcure RRIM for Automotive Exteriors

☛ Michael F. Hurley, Bayer Corporation, Senior Scientist;
Thomas A. Petricko, Exterior Systems
The kinetics of a new material, Bayflex 190 are such that it is possible to eliminate postcure while maintaining key properties and characteristics.

conference PRESENTATIONS

Biocomposites

Injection Moldable Long Natural Fiber Reinforced Polypropylene for Automotive Applications

☞ J. L. Thomason, Owens Corning Automotive Solutions Center, Belgium, T. Cheney, J. Williams, and Ashish Diwanji, Owens Corning, Automotive Solutions Center, USA
Surface coating or sizings applied to reinforcement fibers are a critical component in the processability and performance characteristics of natural fibers and of the composites subsequently manufactured from them. This paper will review how fiber sizing is critical to the processing - performance balance in natural fiber composites and how a unique combination of sizing and compounding technologies has led to the availability of a number of Injection Mouldable Natural Fiber Systems.

Soy Biobased Materials for Automotive Applications

☞ Professor Richard Wool, Department of Chemical Engineering, University of Delaware, Dr. Richard B. Chapas, Cara Plastics
Cara Plastics and the ACRES group have developed new thermoset resins and composites, adhesives, and foams for use in automotive applications.

Automotive Composite Parts Made with Natural Fibers and Honeycomb Cores

☞ Bayer Polyurethanes

'Green' Biocomposites: Moving Towards More Eco-Friendly Structural Automotive Parts

☞ L. T. Drzal, A. K. Mohanty and M. Misra, Composite Materials and Structures Center, Department of Chemical Engineering and Materials Science, Michigan State University
This presentation will give an overview of the important interrelated issues of biopolymer selection, biofiber selection and surface treatment, and biocomposite processing method necessary for achieving acceptable 'green' biocomposite materials.

Biobased Polyurethanes from Plant Oil-Based Polyols: Physico-Mechanical Properties Evaluations

☞ M. Misra, L. T. Drzal, A. K. Mohanty, L. Belchler, G. Mehta, J.-P. Latere Dwan'lsa, Composite Materials and Structures Center, Michigan State University
This paper will discuss research into various bio-based thermoset resins and their composite materials produced by blending resins such as unsaturated polyesters, epoxies and polyurethanes with functionalized vegetable oils.

Engineered BioPlastic Starch Foams – Potential in Automotive Applications

☞ Yogaraj Nabar, Melvin Schindler, and Ramani Narayan, Department of Chemical Engineering & Materials Science, Michigan State University
This paper reports on new environmentally responsible, biodegradable, starch foam with potential in automotive applications.

Growing and Processing Natural Renewable BAST Fibers for Natural Fiber Composites

☞ Hugh S. McKee, President, Flaxcraft Inc.
Natural fibers for composite materials available in commercial quantities and with a range of properties will be discussed.

Painting & Decorating Composites – Panel Discussion

Composites Finishing - The SMC Challenge

Dave Mattis - GM Director of Materials Engineering

Getting SMC Right

Jim Haverland, GM Director Polymers and Painted / Plastics

3C's Program to Make SMC Paint Like Steel

Nippani Rao, DaimlerChrysler, Senior Technical Specialist - Exterior Plastics

Experience and Needs Painting SMC

Ron Kettlehut / Frank Migda, Ford

Toughened Class 'A' SMC

Ken Rusch, Consultant

Making SMC Transparent [to the Paint System]

Jeff Robins, Meridian

Improving SMC for Paintability

Enamul Haque, Owens Corning Automotive

Truck & Transport

Designing for Durability Using an E-Glass Reinforced SRIM Urethane Composite

☞ Scott L. Coguill, University of Wyoming, and Dan Houston, Ford Motor Company
Material evaluation and data summary process provides a means for designing for 10-15 year durability for an E-glass reinforced SRIM Urethane composite.

Development of a Long Fiber Reinforced Composite Seat Structure for Mass Transit Applications

☞ Klaus Gleich, Southern Research Institute and Uday Vaidya, Department of Materials Science & Engineering, The University of Alabama at Birmingham
The paper will show the development of an all composite bus seat using long fiber reinforced thermoplastic materials based on polypropylene and fiberglass co-molded with unidirectional carbon fiber reinforced polypropylene as a local reinforcement as well as the results of the component evaluation.

conference PRESENTATIONS

Bonding Composites

Structural Adhesive Systems Overview

- Michael J. Barker, Ashland Specialty Chemical Company, Specialty Polymers and Adhesives Division

This paper will compare the three primary structural adhesive types, epoxy, acrylic and polyurethane for fit with various substrates, in service conditions and product scenarios. Comparative features will be collected into one easy to use database to aid selection of the best adhesive for the application.

Ultraviolet Light as an Effective Cleaning and Surface Preparation Process for Adhesive Bonding and Painting of Polymers, Composites, and Metals

- Michael J. Rich and Lawrence T. Drzal, Composite Materials and Structures Center, Michigan State University,

This paper reports the utility of using energetic UV light to generate appropriate surface chemical composition on plastics, composites, and metals for subsequent painting or adhesive bonding operations. This UV method has been shown to produce an effective surface treatment with process times of less than 60 seconds, without contacting the surface, requiring no additional chemicals nor releasing VOCs at a cost of ~\$0.01 per square foot of surface treated. Examples will be given.

The Bonding of Engineered Structures in the 21st Century: A New Class of Structural Adhesives

- John Pacanovsky, Sovereign Specialty Chemicals
- A new structural adhesive technology for the fabrication of engineered structures.

Enhanced Bonding of Polypropylene to Polypropylene and other Materials with Novel Thermoplastic Heat Activated Adhesives

- S.W. Tsui, H.M. White and A.F. Johnson, GLUCO Ltd., School of Chemistry, University of Leeds

A new and effective adhesive for the bonding of polypropylene and many other adherents which shows promise for many difficult bonding problems in the automotive and other industrial sectors.

Fiber-Filled Materials and New Flexible Design Methodology for Hybrid Front-End Carriers

- Padraig Naughton, Jan Roettger, Bill Bowser, Samar Teli, Ashish Kotnis, and Eric Kurtycz, Dow Automotive

This paper outlines a new approach to hybrid front-end systems where the metal parts are bonded to the plastic and demonstrates a more flexible and efficient design to get the most out of the hybrid system.

Composites for Fuel Cells & Hybrid Powertrain

Electrochemical and Stack Evaluation of Composite Bipolar Plate Materials

- Joachim Scherer, Raimund Stroebel, Eve Steigerwalt, Dana Corp.
- A study of the corrosion resistance (via electrochemical testing), helium permeation, stack performance, and electrical conductivity of a variety of composite materials designed for bipolar plate applications will be presented.

Development of an All-Composite Tank for High Pressure Hydrogen Storage

- Brent Gerdes, General Dynamics, Lincoln Operations
- A presentation discussing the evolution and development of high-pressure hydrogen storage including performance requirements, design approach and testing of 35 MPa hydrogen storage containers.

Current Technologies and Market Position of Thermoset Bipolar Plates in the U.S.

- John Clulow, Wil Conner, Larry Nunnery, Bulk Molding Compounds
- This paper will explore the available technologies for bipolar plates and discuss the market position of thermoset bipolar plates in fuel cell applications in the US.

Polymeric Composite Bipolar Plates for Vehicle Applications

- Richard Blunk, Mahmoud Abd Elhamid, Daniel Lisi, Youssef Mikhail, General Motors Global R&D Center
- Two approaches are discussed for potentially producing highly conductive and ductile polymeric bipolar plates (PEM fuel cells) using low conductive filler loadings.

Engineered Structural Composite (ESC) Materials in Stiffness-Critical Fuel Cell Applications

- Marc Imbrogno & Brian Hull, Quantum Composites Inc.
- This paper will describe how ESC materials can offer the designer enhanced value by enabling increased functionality, parts consolidation, weight reduction, design flexibility and overall improved performance in key stiffness-critical applications.

Bipolar Plates for Fuel Cell Applications

- Nevil J. Whitty, K. Russell Robson, DuPont Canada Inc. R. & B.D. Centre

This paper will review DuPont's commercial plate development program, properties of DuPont bipolar plates and development efforts underway to develop the next generation of bipolar plates.

A Novel Composite Plate for PEM Fuel Cells

- Mahmoud Abd Elhamid, Youssef Mikhail, Richard Blunk, Daniel Lisi, General Motors Corporation, Global Research & Development Center

The present study investigates a "sandwiched" bipolar plate concept in which stainless steel foil reinforces and seals expanded graphite foil.

Fuel Cell Applications Update

- Tony Androsky US Fuel Cell Council

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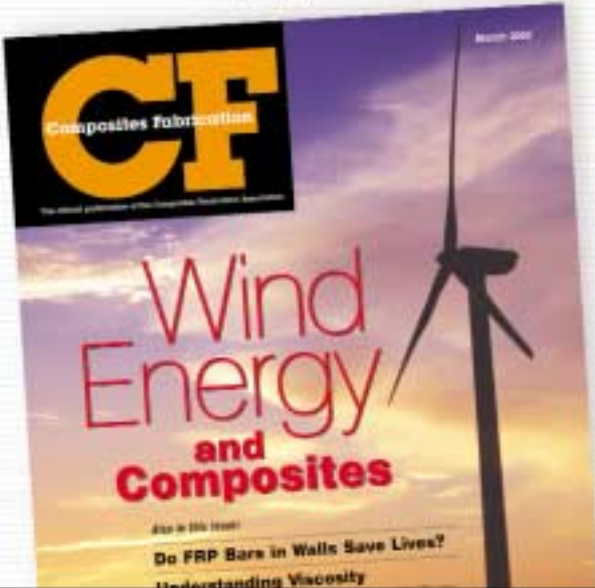
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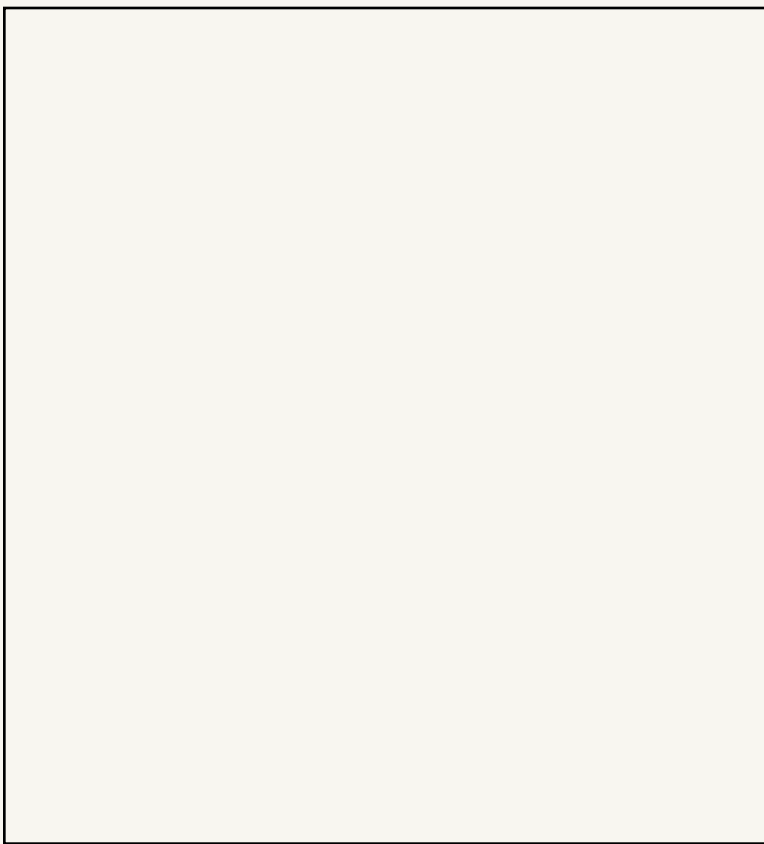

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