University of Delaware
Center for Composite Materials

UPDATE
MAY 2015

CCM Teams with National Highway Safety Administration (NHTSA) & BMW

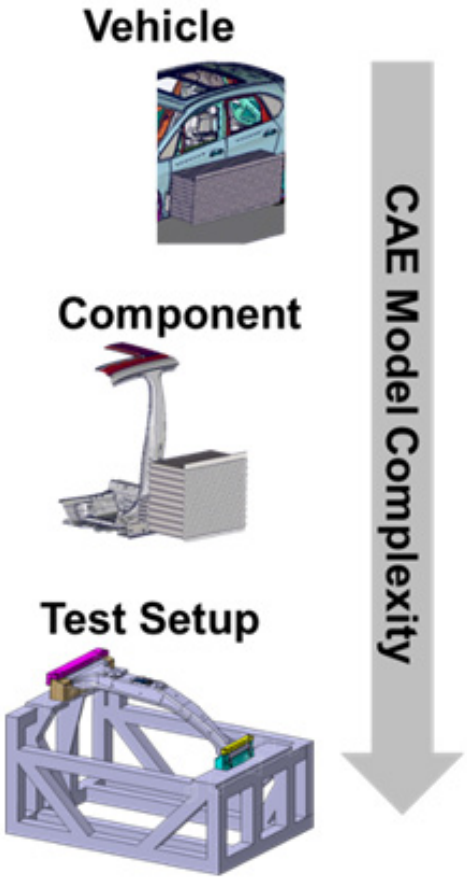
COMPOSITES UPDATE

University of Delaware
Center for Composite Materials

High Performance Computing Study for Composite Intensive Vehicle Design

Composites is one of the practical solutions to achieve overall weight reduction in vehicle structures to meet future fuel economy and emission standards, while robustly fulfilling safety requirements. The National Highway Safety Administration (NHTSA) supports the development and demonstration of predictive engineering tools to evaluate and optimize crash safety of composites structural components. UD-CCM and BMW lead the technical development of the recently awarded "High Performance Computing Study for Composite Intensive Vehicle Design" study to design, manufacture and test CFRP intensive vehicle components. The National Center for Manufacturing Sciences (NCMS) is administering the program.

The team investigates thermoplastic (TP) carbon fiber reinforced materials for vehicle side frame structures. The proposed B-pillar will be designed to meet structural and crash safety requirements (e.g. FMVSS214 barrier) using TP composites which offers significant advantages (e.g. recycling, joining) compared to thermoset with the potential for improved crash performance. State-of-the-art CAE tools simulating full vehicle to component & test setup behavior are used to optimize manufacturability and structural/crash performance. "The design of the B-pillar



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TOP STORY
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will be followed by the manufacturing and testing of a prototype at UD-CCM and validation of our predictive engineering tools. The goal of the program is to attain equal or better occupant safety performance at reduced weight as equivalent vehicle components in the market today," said Dr. Ulrich Veh, BMW Group.

Novel side impact crash concepts maximizing crash performance are developed and commercial available TP materials are characterized to define appropriate material models and to evaluate energy absorption mechanisms. Predictive engineering at all levels, from coupon to sub-element to full-scale, guides the material down-selection. Sub-components and B-pillars will be fabricated at UD-CCM using the stamp forming process allowing scalability with the potential to meet automotive production rates in the future. The processing approach affects local material properties, impacting performance. Finally, UD-CCM's large drop tower is used to validate the predictive engineering tools and crash performance of the proposed B-pillars under realistic side-impact crash conditions. "UD-CCM is excited to team up with NHTSA, BMW and NCMS on this important program to reduce vehicle weight while maintaining safety," said Dr. Jack Gillespie, Director UD-CCM. "The holistic approach looks at new composite materials and processes for automotive applications with the ultimate goal to increase confidence in the predictive design tools available to the automotive community."

NEWS

US Senator Chris Coons visits CCM's Composites Manufacturing Science Laboratory

On March 30, 2015 Senator Christopher Coons visited UD's Center for Composite Materials to tour the center's advanced manufacturing and materials characterization facilities. While touring the center's Composites Manufacturing Science Laboratory he learned about the cutting-edge research ranging from robotic placement of composite layers to smart composites with integrated carbon nanotube sensors.

Senator Coons recently introduced the Manufacturing Skills Act, a bipartisan bill that promotes manufacturing education and workforce training reform. "There are hundreds of thousands of currently unfilled high-skilled, high-wage manufacturing job opportunities in the United States," said Coons.

This fall Coons received an award from The Science Coalition, a nonpartisan, nonprofit organization comprised of the nation's leading research universities. The award recognized Coons' strong commitment to funding the basic research that keeps the U.S. and the State of Delaware at the forefront of scientific discovery and technological innovation.

"For over 40 years CCM has been a leader in composites education, research and technology transfer. By leveraging our unique manufacturing facilities and broad expertise in composites manufacturing we have collaborated over 350 companies ranging from materials suppliers to end users," said Jack Gillespie, CCM's director. "Through our research and educational programs we actively transfer technology, accelerate commercialization, create new jobs in the state and nation, and educate the composites manufacturing workforce."

As Coons toured the laboratory he met with students, faculty, and research scientists and received hands-on experience with composites technology, trying on our composite upper body support system developed for soldiers and using a next generation NHL composite hockey stick to make a wrist shot.

Key highlights of the tour included:

Senator Coons trying on the Integrated Textile Reinforced Upper Body Support System (iTRUSS). This was developed for the Defense Advanced Research Projects Agency (DARPA) Warrior Web program's warfighter-wearable and quasi-active suit systems to improve warfighter effectiveness and reduce injury.

NEWS
(Continued)

US Senator Chris Coons visits CCM's Composites Manufacturing Science Laboratory

Senator Coons scores a hat trick practicing his wrist shot using a next generation NHL Hockey Stick developed with our industrial partner Warrior Sports. The tick stick incorporates our sensors and wireless transmitters for recording energy storage and shot efficiency.

Examining the prototype of the Advanced Passive Dynamic Ankle-Foot Orthoses (PD-AFO) for Wounded Warriors, also sponsored by DARPA. The goal of this program is to develop rapid automated manufacturing technologies for composite PD-AFOs that can demonstrate order of magnitude reductions in cycle time, while improving performance characteristics, individual customizability and affordability.

Meeting the Mechanical Engineering graduate students who took first place in the 2014 SAMPE Bridge Contest, I-Beam Carbon category. The contest allows students to design, build, and test a miniature structural bridge using various composite materials in accordance with a set of well defined rules. This is an international competition involving schools from around the globe. Students compete for monetary prizes and for the coveted SAMPE Student Bridge Champion trophy.

NEWS

In Memoriam: Richard Patrick Wool

The Center for Composite Materials mourns the passing of Professor Richard P. Wool, age 67, who died unexpectedly on Tuesday, March 24, 2015.

Prof. Wool came to the University of Delaware 20 years ago from the University of Illinois at Urbana-Champaign, drawn by a directorship at the Center for Composite Materials and a chance to work more closely with industry. At the center, and in his Affordable Composites from Renewable Sources (ACRES) laboratory, he and his colleagues and students created revolutionary industrial materials with reduced impact on the environment and human health.

"Richard was an outstanding teacher, researcher, adviser and mentor," said John W. (Jack) Gillespie, director of the Center for Composite Materials. "He was also founder of Affordable Composites from Renewable Sources, for which he was world renowned."

"We will remember Richard for his many academic and professional accomplishments, but even more for his legacy as a gentle soul, a mentor, and a positive, guiding force in our campus community," said Provost Domenico Grasso.

"Richard was a remarkable scientist, engineer and researcher," said Babatunde Ogunnaike, dean of the College of Engineering and William L. Friend Chaired Professor of Chemical Engineering. "But above all of that, he was a genuinely good person. He was truly one of a kind and a blessing to those of us who had the great honor of knowing him."

Abraham Lenhoff, Allan P. Colburn Professor of Chemical and Biomolecular Engineering and chair of the Department of Chemical and Biomolecular Engineering, said, "Richard's passion for developing materials from renewable resources included mentoring the next generation of green engineers, and made him a highly visible spokesman for the area. At UD his elective courses in bio-based materials and green engineering were enormously popular with students in chemical engineering and beyond. We will miss his irrepressibly positive outlook, good humor and, of course, his leadership of a very important field in our discipline."

Prof. Wool was born in Cork, Ireland in 1947. Wool met his wife, Deborah Fitzgerald Wool, at University College Cork Ireland in 1969 and moved to the United States where they married and started a family. He received his bachelor of science honors degree in chemistry at the University College Cork Ireland in 1970 and his master's degree (1972) and doctorate in materials science and engineering (1974), both from the University of Utah. After

NEWS
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teaching at the University of New York and the University of Colorado, Richard and Deborah moved to the University of Illinois, where they lived for 18 years and started a family with their three daughters Sorcha, Meghan and Breeda. In 1995, the family moved to Delaware and Richard taught as a Professor of Chemical and Biomolecular Engineering at the University of Delaware until his passing.

Some of his professional accomplishments include: winning the EPA's Presidential Green Chemistry Challenge Award plus being elected Fellow of the Royal Society of Chemistry and the American Physical Society, Division of High Polymer Physics. He published over 150 papers, wrote 2 books, and held 4 patents. He was a guest Professor in the Physics Department, Trinity College Dublin, 2002, the Ecole Polytechnique, Condensed Matter Physics, Paris, France, 1991 and the Politecnico DiMilano, Natta Laboratory, Milan, Italy, 1984.

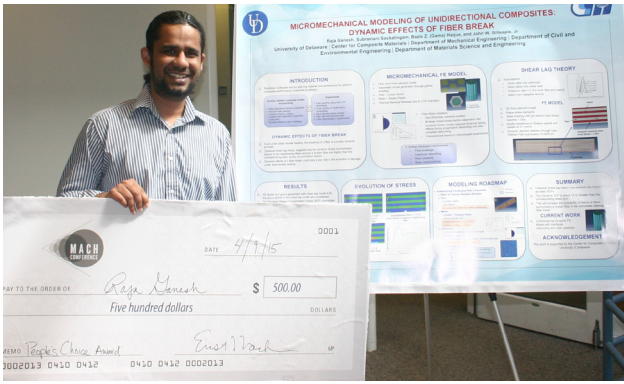
Prof. Wool had many accomplishments throughout his personal and professional life. He brought great joy to everyone with his generosity, kindness, humor, music, wisdom, and love of life. A life-long sailor he treasured the times he could bring others with him to enjoy his favorite pastime. His guitar music sessions were special gifts enjoyed by many throughout the years. His daughters feel extremely grateful for such an incredible father, who always took care and time for them regardless of how busy he was with work.

Memorial contributions may be made to the Dr. Richard Wool Award for Women in Green Chemistry, c/o the University of Delaware Development Office, Development and Alumni Relations Gifts Receiving and Processing Office, 83 East Main Street, 3rd Floor, Newark, DE 19716.

NEWS

2015 MACH Conference - People's Choice Award Winner

Raja Ganesh, PhDME, won the People's Choice Award for best student poster at the 2015 MACH Conference, held in Annapolis, MD, April 8-10, 2015. Presented by the Hopkins Extreme Materials Institute, the MACH Conference showcases the state of the art of multiscale research in materials, with an emphasis on advancing the fundamental science and engineering of materials and structures in extreme environments. Ganesh's winning poster, titled "Micromechanical Modeling Of Unidirectional Composites: Dynamic Effects Of Fiber Break", was one of 36 posters voted on by conference attendees and he received a $500 award. Ganesh is advised by Professor John W. Gillespie Jr., Director of the Center for Composite Materials (CCM).



A Short Course on

Progressive Composite Damage Modeling in LS-DYNA Using MAT162

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Monday, June 8, 2015 | 9am-5pm
Cost: $595 per person
Includes: Coffee, Lunch, Parking, CD with course Content

Description:
Progressive damage modeling of composites under low velocity impact and high velocity impact is of interest to many applications including car crash, impact on pressure vessels, perforation and penetration of thin and thick section composites. MAT162 rate dependent progressive composite damage model in LS-DYNA is considered as the state of the art. This short course will include the theory and practice of MAT162 composite damage model with applications to low and intermediate impact velocities, understanding the LS-DYNA programming parameters related to impact-contact, damage evolution, perforation and penetration of thin- and thick-section composites with and without curvature. The following topics will be covered in this one-day short course with illustrative examples. A CD with content of the course will be provided.

Topics Covered in this Short Course:

Introduction to LS-DYNA
Writing a structured LS-DYNA keyword input deck from scratch for a unit single element (USE) under tension, compression, and shear

Introduction to Continuum Mechanics and Composite Mechanics
Concepts of large deformation finite strain theory
Deformation gradient
Cauchy-Green strain tensors
Piola-Kirchhoff and Cauchy stress
Stiffness matrix for orthotropic and anisotropic composite materials

Composite Material Models in LS-DYNA for Shell and Solid Element

Theory and Practice in MAT162 Progressive Composite Damage Model
Unit Single Element analysis

Low Velocity Impact (LVI) and Compression after Impact (CAV) Applications
For Shell and Solid Elements

Perforation Mechanics of Thin-Composites with MAT162 and Solid Elements

Penetration Mechanics of Thick-Composites
Depth of Penetration Experiments
Ballistic Impact Experiments

Application of MAT162 in Engineering and Research Problems
Impact on Composite Cylinders and Spheres with and without Internal Pressure and/or Blast Pressure
Penetration and Perforation of Sandwich Composites
Normal and Oblique Impact
Multi-Hit Ballistics
Meso-Mechanical Modeling of Woven and 3D Composites

CLICK HERE TO REGISTER

NEW PUBLICATIONS

JOURNALS

Chowdhury, S. C., G. R. Swenson, B. Z. (Gama) Haque, and J. W. Gillespie, Jr., "Molecular Dynamics Simulations of Single-Walled Carbon Nanotube Bundle under Mechanical Loading," FEATURE ARTICLE. SAMPE Journal, 51 (3), May/June 2015.
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http://www.cuet.ac.bd/merj/files/MERJ-Vol-9,%202013,%20page%2037-42.pdf

Gao, X., J. W., Gillespie, Jr., R. E. Jensen, W. Li, B. Z. (Gama) Haque, S. H. McKnight, "Effect of Fiber Surface Texture on the Mechanical Properties of Glass Fiber Reinforced Epoxy Composite," Composites:Part A (2015),
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Kelly, G. S., S. G. Advani, J. W. Gillespie, Jr., "A Model to Describe Stick-Slip Transition Time during Ultrasonic Consolidation," Int. Journal of Advanced Manufacturing Technology,
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Yeager, M. and S. G. Advani, "Numerical Model of Fiber Wetting with Finite Resin Volume," Integrating Materials and Manufacturing Innovation, 4 (3), March 2015.
http://dx.doi.org/10.1186/s40192-015-0032-1

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Yeager, M., R. Ganesh, S. Yarlagadda, S. Advani, J. W. Gillespie Jr, "A Unit Cell Model to Predict Impact of Geometric and Processing Parameters on Energy Absorbed by Fiber Composites", MACH Conference, Annapolis, MD, April 8-10, 2015.

CONSORTIUM NEWS

We would like to thank Fenner Precision, Manheim PA and JML Engineering, LLC, Newark, DE for their recent membership renewal and all our current members for continuing to participate in CCM's research and development activities.

To learn more about the benefits of becoming a member, please visit us on the web at http://www.ccm.udel.edu/industry/industry-partnerships/

CELEBRATING 41 YEARS OF SIGNIFICANT CONTRIBUTIONS TO COMPOSITES SCIENCE AND TECHNOLOGY, THE EDUCATION OF STUDENTS, AND THE CREATION AND TRANSFER OF TECHNOLOGY TO INDUSTRY.

41st Anniversary
Celebrating 41 years of significant contributions to science and technology, the education of students, and the creation and transfer of technology to industry
1974-2015

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UNIVERSITY OF DELAWARE
CENTER FOR COMPOSITE MATERIALS

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