Researchers Develop New Test Method for High-Velocity Water Jet Impact

Raindrops may seem harmless enough when they're falling on our heads, but they're not quite so innocuous when they hit aircraft moving at high speeds.

University of Delaware
Center for Composite Materials

COMPOSITES UPDATE
APRIL 2012

The damage caused when this occurs, known as rain erosion, has been a concern of the aerospace industry since the 1940s. Rain erosion resistance is a critical parameter of materials for aviation and missile applications, and a number of tests have been developed to evaluate materials for this property.

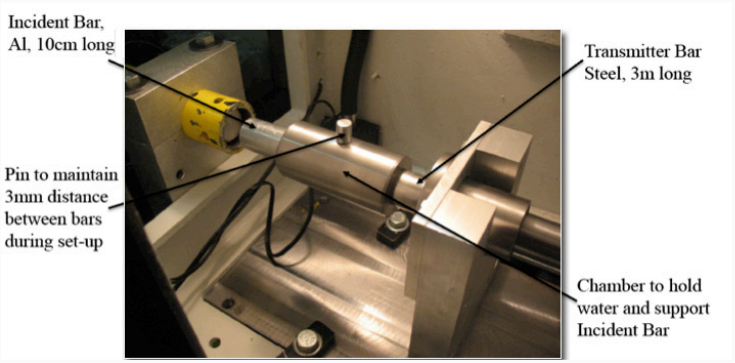
A shortcoming of some existing tests is the need for complicated and expensive equipment. Others lack the ability to reach water jet speeds higher than Mach 2 to 3, so they are inadequate for evaluating material stability or failure mechanisms for the speed range of interest for the modern application.

Dr. Sergey Lopatnikov has proposed a simple method of generating a high-speed short water jet to more accurately mimic the interaction of water droplets with fast-moving bodies. Lopatnikov joined the University of Delaware Center for Composite Materials in 2000. He is a theoretical physicist and former head of branch and the laboratory of mathematical modeling of the All-Union Institute of Nuclear Geophysics and Geochemistry in Moscow,

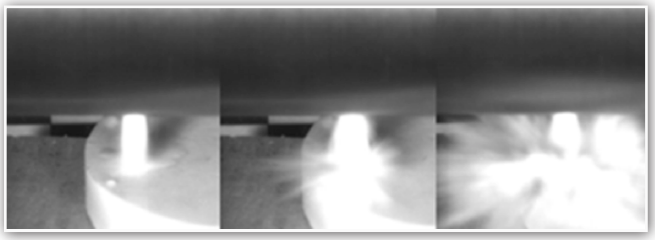
TOP STORY (Continued)

Russia. Over the past decade he has conducted research in a variety of areas including materials subjected to extreme dynamic events and wave propagation in poroelastic materials.

According to Lopatnikov, the proposed apparatus—called the Split Bar Water Jet Generator (SBWJG)—is a highly modified version of the Split-Hopkinson Pressure Bar (SHPB). With the SBWJG, the "sample" consists of a water layer contained by a cylindrical shell with a single nozzle. The material properties, sizes and the geometry of the striker, incident and transmission bars are specially designed to accelerate the sample and generate high velocity jet.



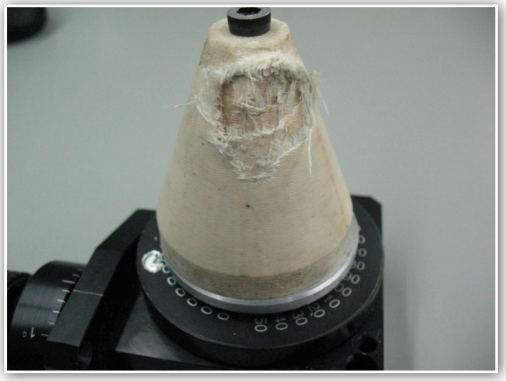
SBWJG apparatus



High speed image of water jet traveling at Mach 3.3

"In theory, the SBWJG has advantages over the standard Single Impact Jet Apparatus, or SIJA, because it 'over-compresses' the water layer sandwiched between high-impedance bar materials," Lopatnikov says. "Also, the method is very inexpensive. The 'sled test,' which is used to measure rain erosion at speeds in the range of 1200 to 1500 meters per second is very expensive compared to our laboratory test method.

To date, a test apparatus has been designed and developed in collaboration with Mentis Sciences, Inc. to demonstrate that the theoretical advantages of the SBWJG method are realized in application.



Water jet impact on composite sample induces significant damage.

The team has also conducted some experiments to demonstrate the feasibility of the new method. In agreement with theory, a speed of 1100 m/sec—Mach 3.3 has been achieved. The results have been published recently in the Journal of Experimental Mechanics Journal (The New Test Method for High Velocity Water Jet Impact. : S.L. Lopatnikov, J.W. Gillespie Jr., C. Morand, R. Lumpkin and J. Dignam DOI 10.1007/s11340-012-9608-2).

"The next step in the development of this technique," Lopatnikov says, "is simply to reach the highest water jet speed possible. With this method, we should be able to generate water jets reaching speeds in the range of Mach 5 to 7."

OTHER NEWS

UDaily

Composites Visionary: Jon DeVault Wins 2012 Jud Hall Awaard for Contributions in Composite Materials

By Diane Kukich

Jon DeVault, 2012 recipient of the Jud Hall Composites Manufacturing Award

2:12 p.m., April 10, 2012--Prime mover, career shaper, composites visionary. These are some of the phrases used to describe Jon DeVault, recipient of the 2012 J.H. (Jud) Hall Composites Manufacturing Award from the Society of Manufacturing Engineers. The award was presented to DeVault at Composites Manufacturing 2012, in Mesa, Ariz., on March 14.

DeVault was introduced at the awards ceremony by Jack Gillespie, director of the University of Delaware Center for Composite Materials (CCM), who received the same honor in 2000. The award is given annually to an individual who has "contributed to the composites manufacturing profession through leadership, technical developments, patents, or educational activities."

At left, Jon DeVault, 2012 recipient of the Jud Hall Composites Manufacturing Award from the Society of Manufacturing Engineers, with Jack Gillespie, director of UD's Center for Composite Materials.

As an employee at Hercules in the 1970s, DeVault helped found CCM's industrial consortium. Later, in the 1990s, he supported CCM's involvement in programs funded by the Defense Advanced Research Projects Agency (DARPA), including the use of composites in infrastructure applications.

"Under Jon's leadership," Gillespie said, "Hercules became the largest supplier of graphite materials to the Department of Defense, as well as a manufacturer of composite structures. He was also instrumental in developing the automated fiber placement manufacturing technology and in expanding the composites business worldwide."

In his introduction, Gillespie not only enumerated DeVault's many accomplishments and leadership roles but also shared comments about him from other giants in the composites field, including three with connections to UD.

Former dean of engineering Byron Pipes, a member of the National Academy of Engineering (NAE), referred to DeVault as the champion of a "new miracle material"—high tensile strength carbon fiber—in the early 1970s when boron filament was the state of the art.

Click HERE to read the entire UDaily article.

News

UDaily

AIMBE Fellow
College of Engineering's Kristi Kiick selected as AIMBE Fellow

9:03 a.m., March 16, 2012--Kristi Kiick, deputy dean of engineering and professor of materials science and engineering and biomedical engineering at the University of Delaware, has been inducted into the American Institute for Medical and Biological Engineering (AIMBE) College of Fellows, Class of 2012.

This elite appointment distinguishes Kiick among the top two percent of her peers. AIMBE College Fellows include the top 1,000 outstanding bioengineers in academia, industry and government.

Click here to read the entire article in UDaily.

Photo by Lloyd Wolf, courtesy AIMBE

Pictured are (from left) Alan Russell, AIMBE College of Fellows Chair (2011-12), UD's Kristi Kiick and Ken Lutchen, AIMBE president (2011-12).

Inaugural Medal of Excellence Winner Honored with Franklin Medal

Zvi Hashin, Professor Emeritus in the School of Mechanical Engineering at Tel Aviv University in Israel, has been selected to receive the 2012 Benjamin Franklin Medal in Mechanical engineering.

Hashin was one of four inaugural recipients of the Medal of Excellence in Composite Materials, granted by UD-CCM. Established in 1984 in conjunction with the Center's decennial celebration, the composites medal recognizes those who have maintained and demonstrated scholarly endeavor, invention, and/or economic enterprise over a sustained period of time.

As winner of the 2012 Franklin Medal, Hashin will anchor a symposium on the development and utilization of micromechanics analysis of composite materials. The event will be held at Villanova University on Wed., April 25.

Presentations will cover the history of the development of the field of micromechanics of composite materials and the material and structural design revolution resulting from this work.

One of the symposium presenters—Walter Rosen, former president of Materials Sciences Corporation in Ambler, Penn.—is also a previous Medal of Excellence in Composites recipient.

The Franklin Institute Awards are among the oldest and most prestigious comprehensive science awards in the world. Recognizing "brilliant men and women from around the world" is one important way that the Institute preserves Benjamin Franklin's legacy.

Professor Zvi Hashin, Recipient of the 1984 Medal of Excellence in Composite Materials and 2012 Benjamin Franklin Medal in Mechanical Engineering.

Click here to view the Villanova University Symposium flyer.

JOB OPPORTUNITIES

The Center for Composite Materials in the College of Engineering at the University of Delaware is currently recruiting applicants for:

1 **POSTDOCTORAL RESEARCHER** position in the areas of thermoplastic process modeling. Qualifications include a PhD in engineering or related field with an emphasis on polymer composites. Applicants are required to be knowledgeable in thermoplastic processing (PEEK, PEKK, PEI), first principle process modeling and finite element analysis. Hands on experience in fabricating and testing of composites is required. Good written and oral communication skills are required, along with the ability to interact effectively with industrial sponsors, government sponsors, and other CCM staff and students.

2 **POSTDOCTORAL RESEARCHER** position in the areas of numerical analysis & design and/or process modeling and manufacturing science of composite materials structures. Qualifications include a PhD in engineering or related field with an emphasis on polymer composites. Applicants are required to be knowledgeable in finite element analysis and current state-of-the-art FEA software, possess a solid understanding of the basic principles of structural mechanics and be able to apply these principles to composite structures. Hands on experience in fabricating and testing of composites are also a plus. Good written and oral communication skills are required, along with the ability to interact effectively with industrial sponsors, government sponsors, and other CCM staff and students.

To apply, please submit cover letter and resume to Corinne Hamed, **hamed@udel.edu.**

Founded in 1974 within the University of Delaware's College of engineering, the Center for Composite Materials (UD-CCM) is an internationally recognized, interdisciplinary center of excellence for composites research and education. UD–CCM has extensive capabilities ranging from basic research through specific applications, clearly encompassing applied research that serves to transition basic research to products and applications. The Center has a broad range of state- of-the-art advanced equipment housed in two dedicated buildings for composites basic and applied research. Sponsored research expenditures are over $12M annually. CCM is host to seven (7) NSF/DoD Centers of Excellence since 1986.

3 **LIMITED TERM RESEARCHER** position in the areas of numerical analysis & design and/or process modeling and manufacturing science of composite materials structures. Qualifications include a Masters in engineering or related field with an emphasis on polymer composites. Applicants are required to be knowledgeable in finite element analysis and current state-of-the-art FEA software, possess a solid understanding of the basic principles of structural mechanics and be able to apply these principles to composite structures. Hands on experience in fabricating and testing of composites are also a plus. Good written and oral communication skills are required, along with the ability to interact effectively with industrial sponsors, government sponsors, and other CCM staff and students.

NEW PUBLICATIONS

Journals

Abu Obaid, A., J. M. Deitzel, J. W. Gillespie, Jr. and J. Q. Zheng, "The Effects of Environmental Conditioning on Tensile Properties of High Performance Aramid Fibers at Near-Ambient Temperatures," Journal of Composite Materials, doi: 10.1177/0021998310381436, 45 (11), pp. 1217-1231, June 2011. **Click here to read abstract.**

Alfredsson, K. S., A. A. Gawandi, J. W. Gillespie, Jr., L. A. Carlsson, and R. A. Bogetti, "Stress Analysis of Axially and Thermally Loaded Discontinuous Tile Core Sandwich With and Without Adhesive Filled Core Gaps," Composite Structures, doi:10.1016/j.compstruct.2011.01.015, 93, pp. 1621-1630, June 2011. **Click here to read full paper**

Chowdhury, S. C., B. Z. Haque, T. Okabe, and J. W. Gillespie Jr., "Modeling the Effect of Statistical Variations in Length & Diameter of Randomly Oriented CNTs on the Properties of CNT Reinforced Nanocomposites," Composites: Part B, 43 (4), pp. 1756-1762, January, 2012. **Click here to read full paper**.

Gama, B. A. and J. W. Gillespie, Jr., "Finite Element Modeling of Impact, Damage Evolution and Penetration of Thick-Section Composites," International Journal of Impact Engineering, doi:10.1016/j.ijimpeng.2010.11.001, 38, pp. 181-197, April 2011.
Click here to read full paper.

Gawandi, A., E. T. Thostenson, and J. W. Gillespie, Jr., "Tow Pullout Behavior of Polymer-Coated Kevlar Fabric," Journal of Materials Science, doi:10.1007/s10853-010-4819-3, 46, pp. 77-89, January 2011. **Click here to read full paper.**

Koellhoffer, S., J. W. Gillespie., Jr., Travis A. Bogetti, and S. G. Advani, "Role of Friction in the Thermal Development in Ultrasonically Consolidated Aluminum Foils and Composites," Journal of Materials Processing Technology, doi:10.1016/j.jmatprotec.2011.06.011, 211, (11) pp. 1864-1877, November 2011. **Click here to read full paper**.

Lim, A. S., S. L. Lopatnikov, N. J. Wagner, and J. W. Gillespie, Jr., "Phenomenological Modeling of the Response of a Dense Colloidal Suspension under Dynamic Squeezing Flow," Journal of Non-Newtonian Fluid Mechanics, doi:10.1016/j.jnnfm.2011.03.005, 166 (12-13), pp. 680-688, July 2011. **Click here to read full paper**.

Lopatnikov, S. L., J. W. Gillespie, Jr., C. Morand, R. Lumpkin, and J. Dignam, "The New Test Method for High Velocity Water Jet Impact," Experimental Mechanics, doi:10.1007/s11340-012-9608-2. **Click here to read full paper**.

Manzella, A. F., B. A. Gama, and J. W. Gillespie, Jr., "Effect of Punch and Specimen Dimensions on the Confined Compression Behavior of S-2 Glass/Epoxy Composites," Composite Structures, doi.org/10.1016/j.compstruct.2010.11.006, 93, pp. 1726-1737, June 2011. **Click here to read full paper.**

McAllister, Q. P., J. W. Gillespie, Jr., and M. R. VanLandingham, "Evaluation of the Three-Dimensional Properties of Kevlar Across Length Scales", Journal of Materials Research, doi: 10.1557/jmr.2012.80, March 2012. **Click here to read full paper**.

Nilakantan, G., E. D. Wetzel, T. A. Bogetti, J. W. Gillespie, Jr., "Finite Element Analysis of Projectile Size and Shape Effects on the Probabilistic Penetration Response of High Strength Fabrics," Composite Structures, doi:10.1016/j.compstruct.2011.12.028, 94, pp. 1846–1854, 2012. **Click here to read full paper**.

Nilakantan, G., M. Keefe, E. D. Wetzel, T. A. Bogetti, and J. W. Gillespie, Jr., "Computational Modeling of the Probabilistic Impact Response of Flexible Fabrics," Composite Structures, doi:10.1016/j.compstruct.2011.06.013, 93, (12) pp. 3163-3174, November 2011. **Click here to read full paper.**

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CONSORTIUM NEWS

We would like to thank our many consortium 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 **www.ccm.udel.edu/Consortium/benefits.html**

Celebrating 38 years of significant contributions to composites science and technology, the education of students, and the creation and transfer of technology to industry.

This is a newsletter publication of the University of Delaware Center for Composite Materials
Please visit us on the web at **http://www.ccm.udel.edu**

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