PHANTOM®

2020
CASE STUDY

Revealing Their True Colors

Researchers have developed a novel specimen tracking method using a Phantom high-speed color camera—putting a new spin on traditional measurement techniques.

Dr. Daniel Whisler likes to crash things. When it comes to studying how materials respond to impacts and other extreme loading conditions, that's a good thing. For example, his research informs the development of new, safer materials for human protection.

Whisler is a member of the Impact Group at California State University Long Beach (CSULB), where he studies the dynamic impact behavior of various materials and structures. These materials often include flexible polymer composites, which can be difficult to measure using traditional sensor-based techniques.

For this reason, Whisler and his team have devised a novel method to measure the dynamic response of composites using high-speed color cameras—putting a new, colorful spin on traditional measurement techniques.

VISION RESEARCH

AMETEK® MATERIALS ANALYSIS DIVISION

THE CHALLENGES OF MEASURING FLEXIBLE COMPOSITES

The Impact Group is part of CSULB's Mechanical and Aerospace Engineering Department. Its research is being applied to many applications, from vehicle crashworthiness to natural disaster protection. Many of the lab's high-stretch composites also simulate biological tissue, enabling the researchers to study how the human body experiences impact without having to use an actual body.

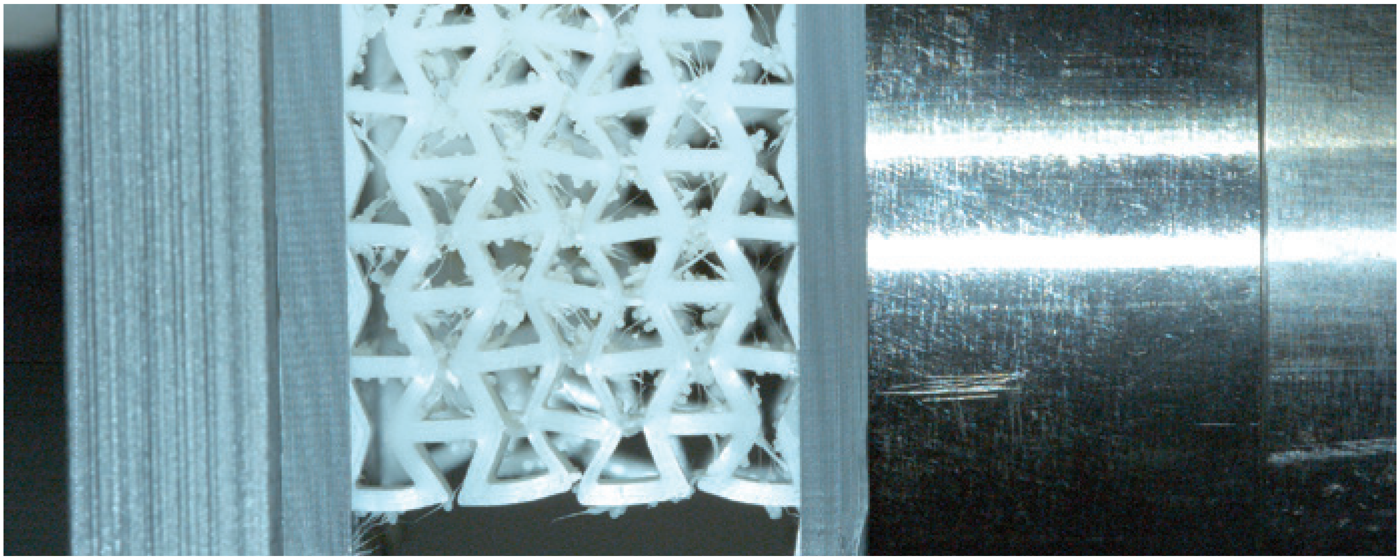
"We look at flexible composites, which are a new class of soft, bendable material," Whisler explains. "Think of car door panels. If you bump a metal door, it dents. But if you bump a flexible plastic reinforced with soft material, the motion bounces right off."

Whisler's research is not without its challenges. For one, the impacts take place at very high speeds, subjecting the specimen material and sensors to high strain rates. "Any time you go fast, you start to break things—from sensors to the material itself," Whisler says. "Because of this, we can't always apply sensors to the types of materials we work with."

A second challenge is the flexible nature of the composites, which makes it difficult to physically attach sensors such as strain gauges. "Some materials are very soft," Whisler says. "Applying a sensor would be like trying to stick a stamp to ice cream." For these reasons, Impact Group researchers have had to move away from relying on sensors to obtain important impact data.

A NEW SPIN ON EXISTING MEASUREMENT TECHNIQUES

Digital Image Correlation (DIC) can be a useful method for evaluating how applied forces affect objects. This technique uses high-speed cameras and specialized software to optically measure deformation, displacement and strain. Instead of sensors, it relies on the application of a speckle pattern to the surface of the object. The cameras and DIC software then record and analyze the pattern's movement in response to an applied force, revealing areas of displacement and strain. Though useful, DIC is not always a feasible method for the types of composites the Impact Group studies.

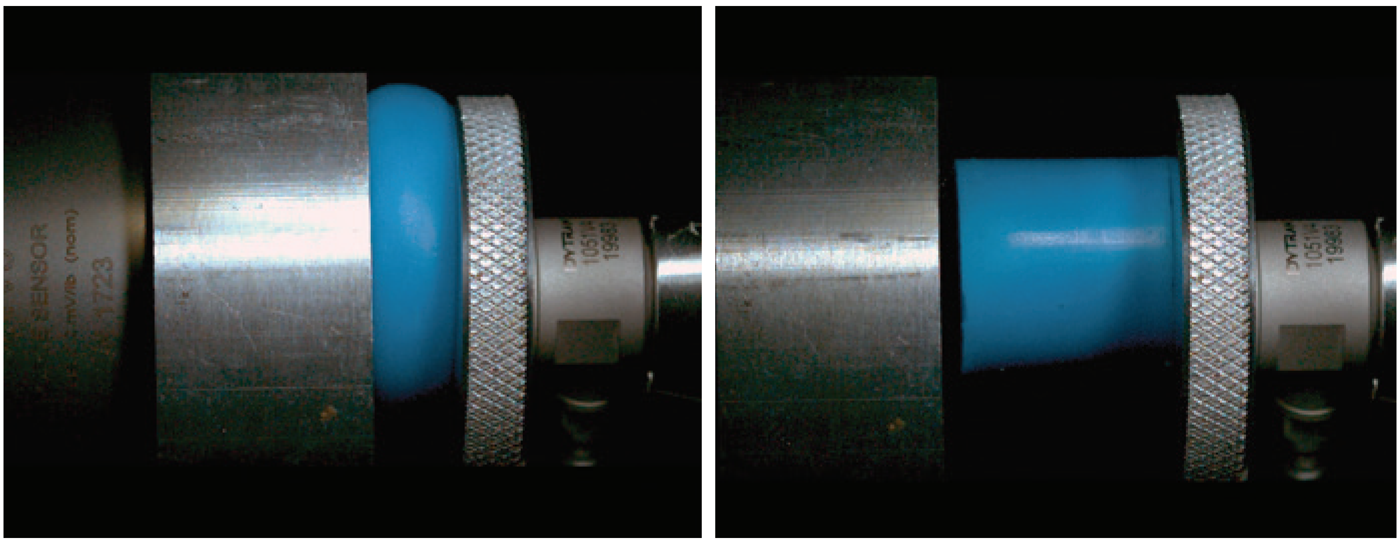


The CSULB Impact Group studies the dynamic impact behavior of various composite materials and structures.

"When performing DIC, you have to prepare the surface of the object you want to study," Whisler says. "This means you have to get the speckle paint just right. But it's hard to paint something soft like ice cream."

Since Whisler and his team can't rely on established techniques, they had to come up with a new measurement method. In particular, they figured out how to extract material data from impact tests without the use of sensors or speckle paint. This new methodology utilizes a high-speed color camera, as well as a new mathematical processing technique.

"We apply a non-contact, speckle-less and custom Matlab script to isolate composite specimens," Whisler says. "Then, using a Phantom v2640 high-speed camera, we film the specimens under uniaxial, low-velocity impact and measure the displacement time history."



Because the composite specimen has a unique color signature compared to its surroundings, the researchers can exactly locate its displacement during impact tests.

THE PHANTOM CAMERA'S COLORFUL ROLE

Critical to Whisler's methodology is the Phantom v2640 color camera, whose CMOS sensor uses a Bayer filter array to perceive color. Red Green and Blue (RGB) color filters are applied to each pixel in a mosaic pattern, providing up to 4,096 levels per color channel compared to the 4,096 levels of gray with a 12-bit monochrome sensor. As a result, the RGB sensor allows Whisler to "see" up to three times more distinguishing features on his test specimens.

"Having three channels of RGB data compared to just one channel of gray lets us more easily isolate the specimen from its surroundings," Whisler explains. "This is accomplished since the specimen has a unique color signature compared to its surrounding environment."

For example, both the specimen and its surroundings might have a gray value of 128—making it difficult to distinguish between the two areas in the high-speed video. But because the specimen has a unique color signature (R:0, G:177 and B:220) compared to its surroundings (R:160, G:200 and B:198), the researchers can exactly locate specimen displacement.

A HIGH-SPEED CAMERA THAT PASSES WITH FLYING COLORS

For his new methodology, Whisler needed a high-speed camera with more than just fast frame rates. He needed a high-resolution camera to provide the required image detail. "Our impact experiments require very fast recording speeds—50,000 to 100,000 frames per second," Whisler says. "These rates are already faster than typical high-resolution cameras can achieve. Already, we found ourselves in a limited market for suppliers that can handle these speeds."

Whisler found his answer in the Vision Research Phantom v2640 Ultrahigh-speed camera, which is the fastest four-megapixel camera available on the market. While its speeds and superior image quality are important, Whisler took advantage of the camera's RGB signal split when developing his new measurement technique. "That was our main application—using the sensor technology itself to help us with specimen identification," he says.

The Phantom v2640 UHS Camera

THE BENEFITS OF THE IMPACT GROUP'S NEW TECHNIQUE

According to Whisler, although this method is still in its infancy, it has so far shown many benefits. First, it eliminates the application of sensors and speckle paint to the soft, flexible composites. It's also an accurate, convenient measurement technique for more complicated experiments—when measuring drag forces in flying objects, for example, or tracking fluid particles. And finally, Whisler concludes that this method is all-encompassing, requiring only a single high-speed color camera to measure both force and displacement.

Perhaps most importantly, this new method challenges the notion that the best, highest-quality images are only possible using monochrome sensors even though it is true they are inherently more light-sensitive, which is an important trade-off to understand. "I believe this new technique opens up new doors—not just for science and specimen tracking, but for the effect it has on people and students," Whisler says. "Black and white images can come off as old, making color images much more relatable. Color really augments the level of our research. It's the best we can do going forward."

Whisler presented his new tracking method at the 2019 technical conference of the American Society for Composites.

*To learn more about Vision Research high-speed expertise and equipment, visit **www.phantomhighspeed.com***