Solve Key Problems in Composite Simulation

Whether you are looking at pre-processing, post-processing or material testing, composites are orders of magnitude more complex than traditional materials such as metal and plastic.

BY MARK CLARKSON

Like a very tricky sandwich, composite materials are usually laminated structures, made up of layers (plies) of material, stacked one on top of the other. These layers often have fibers running through them, and the angle of those fibers can vary from layer to layer (0°, 45°, 90°, etc.). There can be dozens, or even hundreds of layers. There might be more layers in some areas, and fewer in others so the overall width of the structure varies from area to area. The final properties can be hard to predict.

"If you don't have a balanced, symmetric laminate, your part can twist when you apply a tensile load," says Alastair Komus of Composites Innovation Centre. "You can take advantage of that in some parts; other times you want to avoid it entirely. But it's a complication that your software needs to be able to predict."

On a curved part, the effective angle of the fibers can change from place to place. That orientation is a huge factor in analysis, according to Komus: "Siemens NX allows you to define a starting point on your part and, as you drape your material over a curved surface, the program tells you how the alignment of those fibers changes."

Taking a Look

Just being able to see what's going on in a composite structure can be a big challenge, notes Altair Senior Director Robert Yancey, Ph.D.: "Composites add one or two more orders of magnitude to the information you have to be aware of when you analyze a structure."

The same issue persists on the post-processing side, he says.

"Damage usually initiates at a single layer, and you want to be able to quickly home in on where that damage is occurring," Yancey explains. "With Altair, you can color-code the layers. But if each layer has a different fiber orientation and you want to visualize the fiber orientation of a particular layer, you've got to select that layer [and look at it separately]. It works fine, but it's not a very intuitive process right now. I believe there will be more efficient ways of integrating that data."

Analysis of composite compressed natural gas tank doors on a transit bus.
Images courtesy of Composites Innovation Centre.

Optimization Offers Advantage

Yancey points to Altair's optimization technology as being able to guide users with respect to the general structure of the laminate.

"We can tell the designer which angle ply should be where, what angle ply should dominate where in the structure, where you can get away with dropping off some plies, or where you might need to build up some plies in order," he says. "We've been able to demonstrate to many of our customers that you can develop a composite laminate design that can save 15% to 30% of weight over a traditional composite design."

In addition to saving weight and saving materials, think about the complexity of the composite itself, advises Altair Business Development Manager Giuseppe Resta.

"You may have hundreds of plies of different orientations and different thicknesses. The question is, where do you start? There are so many solutions that, in theory, give you a satisfactory design, but where does the engineer go to get the best out of it?" Resta continues. "Optimization guides you to what may not be an intuitive design. Optimization is not just an add-on to improve something that you've already done; it can be a design strategy that you adopt at the beginning to gain insight into how to use this expensive material at its best."

Errors in your Model

"What makes design space exploration possible is a tool that's reliably accurate over the entire design space," observes Scott Leemans, principal engineer at Advatech Pacific. "You have to quantify the uncertainties over the entire design space to ensure that is true."

In general, he says, for complex systems such as aircraft, the traditional finite element analysis (FEA) approach leads to models that are tuned to match tests as the project progresses.

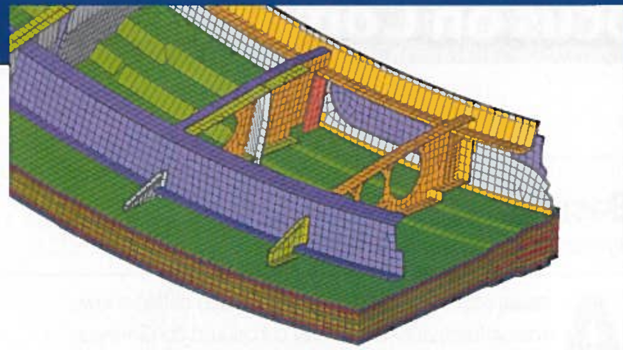
"In other words," says Leemans, "the individual errors are not identified and then quantified over any significant portion of the design space. I do not believe that error quantification is adequately addressed — or even adequately facilitated by most packages. It is left to the user to decide when and how they ensure the accuracy of their models.

"We calibrate, verify, and validate all of the analysis models that go into our tools with testing," he adds. "We use a test matrix that covers the same design space over which the tools are valid."

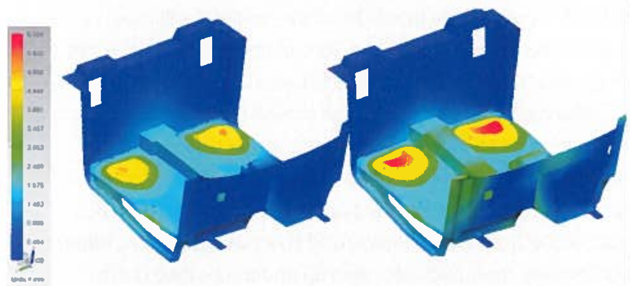
Material Property Problems

There's another problem lurking at the very heart of composite simulation: garbage in, garbage out.

"In CAE, you need a proper input to get a proper output," says Altair's Resta. "We need to have a mature material

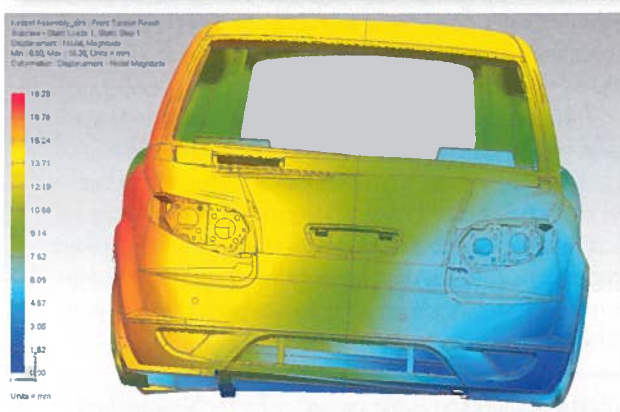


Altair's HyperWorks includes many features to help model and analyze complex composites parts, including 3D representation of plies.



Seat pull analysis for the front tub of the Kestrel concept vehicle.

Roof crush analysis of the Kestrel concept vehicle.



Torsion analysis of the Kestrel concept vehicle.