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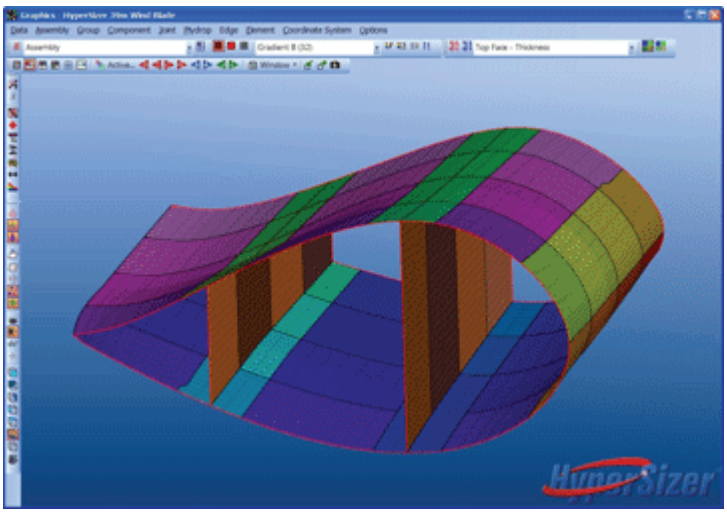
Sandia Sizes up Wind Turbine Blade Design

Armed with HyperSizer optimization software and FEA, Sandia pursues innovations in large wind turbine blade design, aiming for a balance between low weight and structural integrity.

By Beth Stackpole, Contributing Editor, Design Software & Hardware -- Design News, January 24, 2011

By many accounts, wind energy, a relative veteran among alternative energy sources, is well-positioned for a perfect storm around growth: The political climate is favorable, a downtrodden economy is hungry for economical and efficient fossil fuel alternatives and more than 30 years of research and development has been poured into wind energy innovations. Yet one of the remaining barriers to widespread adoption of wind energy is honing that right mix of functionality for a wind turbine blade design that is large enough to support higher performance while retaining a form factor that is economical, reliable and can be produced on a grander scale.

Sandia National Labs, and in particular, the Wind Energy Technologies Dept., finds itself at the epicenter of that design challenge. The group partners with universities and industry to conduct applied research in the area of wind turbines and blades to increase the viability of wind technology. Researchers at the lab are working on advancing knowledge around the areas of materials, structural dynamics, active-flow aerodynamic control and sensors along with pursuing innovations in the manufacturing processes and embedded controls associated with wind blade design.



HyperSizer software works with FEA software in a feedback loop to search for solutions that minimize weight while maximizing structural integrity.

"We're about developing innovation that's five years, maybe 10 years out," says Tom Ashwill, P.E., distinguished member of technical staff at Sandia National Labs' Wind Energy Technologies Dept. "The industry is risk-adverse to innovation - they can only look two to three years out. We look to take risk off the table for them and try things we don't know will work." The Sandia lab makes the results of its innovation efforts available to industry via reports, partnerships and through regular conferences and workshops.

Large-Scale Blade Design

One of the department's primary areas of focus is innovation related to increasing the size of wind turbine blades. In the early 1980s, wind turbines averaged 100 kW, but the current average capacity is around 2 MW - a factor of 15 to 20 times more performance than what existed 25 years ago, Ashwill explains. As demand for performance increases, so does blade size, since blade length has a direct correlation to the increased power generating capacity of a turbine. As far as economics go, the thinking is that fewer, higher-capacity wind turbines are more efficient and cost-effective than creating the infrastructure to support many smaller turbines, Ashwill says.

Click here to read the sidebar "Developing Composite Wind Blades That Will Stand the Test of Time"

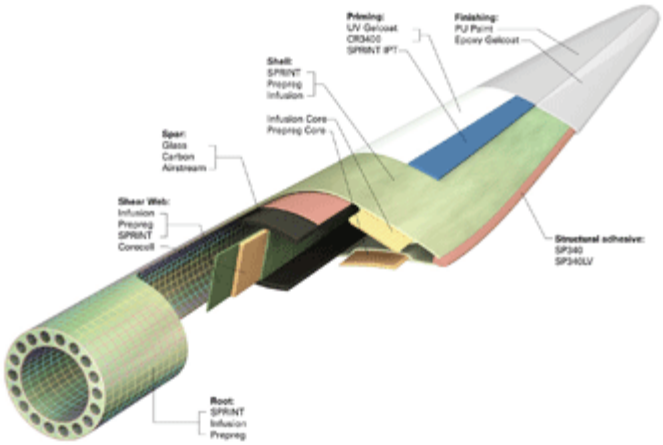
Current utility-scale turbines are equipped with blades that range from 40m (130 ft) to 90m (300 ft) in diameter. Sandia has a research project underway to advance that capacity to a 100m blade, which in a traditional three-bladed turbine design, would encompass a footprint in the order of two-and-a-half football fields in size. This massive blade design, aimed at turbines that would reside 15 miles offshore, creates significant design challenges around weight, structural integrity and manufacturability.

"As they get larger, the weight of these blades becomes an issue," says Craig Collier, president of **Collier Research Corp.**, the maker of software used to optimize composite materials and structural sizing that came out of work done at NASA Langley Research Center and now employed as part of Sandia's research. "As they get larger, the question is: Can they withstand their own weight without breaking? It's a big issue for the design of new blades." In addition to structural strength, design engineering issues associated with the larger blades encompass things like fatigue performance, buckling stability, blade stiffness, twist limits and wing-tip deflection.

HyperSizer's legacy in aerospace has helped entities like NASA and companies like Lockheed Martin, Boeing and

Bombardier, trim at least 20 percent off the weight from wing structures. The software works with out-of-the-box FEA solvers in a feedback loop to identify solutions that minimize weight while maximizing structural integrity and manufacturability, Collier says. The software analyzes complex composite structures by evaluating designs in a ply-by-ply and finite element-by-element manner, helping engineers optimize all possible variations on a composite laminate design.

While FEA will give engineers insight into internal unit loads - for instance, how much air load goes into the skin of a blade or into the spar cap - it does not, for example, provide analysis on overstressed materials or if a bonded joint is going to have a failure. That's where **HyperSizer** comes in, Collier explains. "HyperSizer will not only identify the problem, but will go a step beyond and tell you what to do to fix the problem," he says. "It has built-in intelligence to make those recommendations."



HyperSizer can be used to evaluate ply drop-ff and ply-add patterns to determine the lightest laminate that meets strength requirements with the fewest transitional regions.

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Leveraging HyperSizer's built-in optimization and intelligence capabilities, Sandia plans to refine its baseline design for a 100m blade and optimize parts of the design to reduce weight. The software will be key in exploring how and when to add material variants such as carbon fiber, how to address active or passive load controls, and for experimenting with different air foils as part of the ongoing research effort. Ashwill says he expects industry to release wind turbines based on this blade research about seven to eight years in the future.

"We're just looking to apply innovation to larger blade design as we have in the past for smaller blades," Ashwill says. "HyperSizer will show us how to optimize those designs."

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