

“Quality is Job 1” for Wind Turbine Industry

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A few years ago there was an American automobile company that proclaimed, “Quality is Job 1.” Well, now the same can be said for the wind turbine industry, which is finding that one of the keys to maintaining competitiveness is the ability to continually improve the quality of wind blade design and manufacturing.

It is a high stakes challenge because premature blade failures have the potential to generate a lot of negative attention with a resultant loss of credibility and business, not to mention high litigation costs.

It is also a challenge at the core of the wind blade business, as quality issues invariably increase costs and reduce margins by leading to higher maintenance and lifecycle costs due to part replacements, more repairs and longer down time.

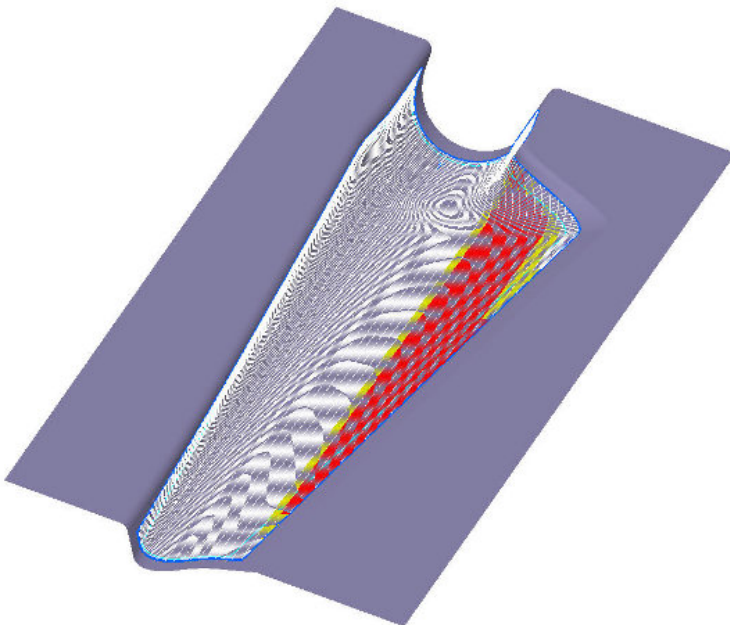
Fighting the trend

The quality challenge in the wind blade industry is compounded by two market trends:

First, the increased pressure from a fast growing market is driving higher production rates. But quality should not be sacrificed in the search for shorter cycle times and faster manufacturing because a bad blade, no matter how swiftly produced, does no one any favors.

Secondly, the average wind turbine size is regularly increasing in hopes of achieving better efficiency. Longer and lighter blades are being designed, pushing the limits of materials, design and manufacturing capabilities. This trend makes it even more imperative that quality be a major consideration in the development of the wind blades.

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This FiberSIM® simulation highlights fiber orientations that deviate from specification when draped over complex curvature. Excessive deviation is highlighted in red (yellow for moderate deviation), alerting engineers to potential performance problems. FiberSIM offers multiple process simulation options for both manual and automated ply deposition.

There are several aspects of the blade development process that can work against better quality.

For instance, taking a conservative design approach with inflated safety factors can result in an over-designed blade with excessive material which can then lead to a weight penalty and reduced wind turbine efficiency. Over design will most likely not compensate for a manufacturing defect. In fact, it may trigger unsuspected modes of failure.

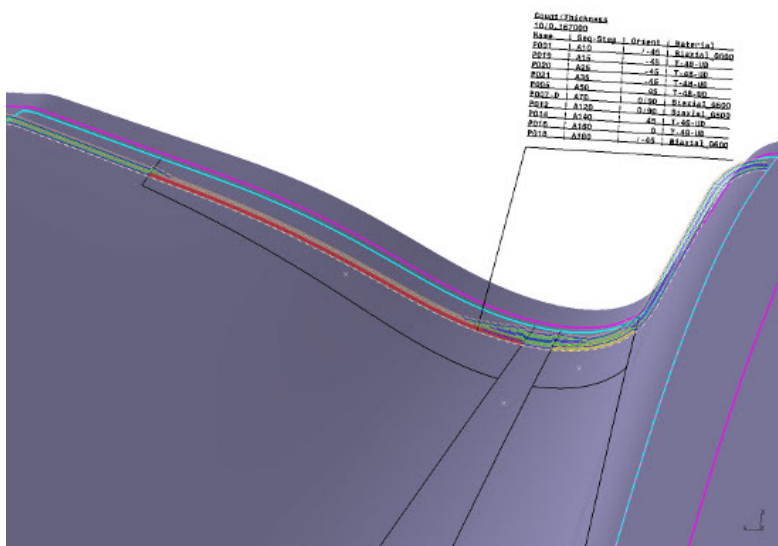
A weak link between design and manufacturing is another aspect of this issue. An incomplete engineering release leaves much room for interpretation and necessitates on-the-fly decision making later in manufacturing, leading to errors and rework that are costly, time-consuming and result in suboptimal and inconsistent manufacturing.

Finally, the manual and verbal transfer of information between design and stress or design and manufacturing often means that design and manufacturing changes are pushed back or left undone due to lack of time and production pressure.

Designing for success

Robust quality improvement rests on a two fold approach: implementing a better design methodology and achieving a more consistent manufacturing process. These two efforts are joined at the hip by the overarching need for a more controlled and seamless development process for composite blades.

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This image shows the cross-section of a wind blade shell laminate. FiberSIM®'s documentation capabilities enable the user to sample the laminate at discrete points with an annotation that includes laminate thickness, ply names, sequences, orientations and materials. The cross-section shows an exploded view of the plies as draped on the manufacturing tool surface. Colors indicate different orientations and materials. Such data is parametric and will automatically update any design change to the FiberSIM model, thereby providing a high level of robustness and flexibility to the development process.

Several aspects of the design can be improved by the use of advanced composites design software, such as FiberSIM®.

Better design entails using a more accurate and detailed representation of the composite blade earlier in the process. With 3D CAD based composite design software, a detailed zone or ply definition is available earlier and can be used for more efficient sizing and optimization. A more accurate mass and stiffness distribution for the blade that is closer to the as-manufactured blade can also be obtained. More time can be spent on optimizing the blade further.

Developing a digital master model of the blade with composite design software will ensure that all

information about the part for detailed design, detailed analysis, and manufacturing, will be easily generated electronically from one single source. In this way, consistency is maintained between disciplines. What is manufactured is what has been designed and analyzed.

Producibility simulation for ply layups can be performed with composite software before any prototype is even built. Fabric wrinkling during layup and other fiber deformations detrimental to the blade integrity can be assessed. In this way, manufacturability is ensured ahead of time, while design is still ongoing, which alleviates the need for a costly trial and error approach. Reducing engineering time and using fewer prototypes are critical to the competitiveness of blade manufacturers.

Furthermore, composite design software supports easy and reliable treatment of numerous design details that are part of the final composite layup definition, such as ply stagger and drop off, ply corner treatment, cored panel definition, multi laminate assembly and ply sequencing. The true quality of the final blade builds off of all these small design details that make or break a good design.

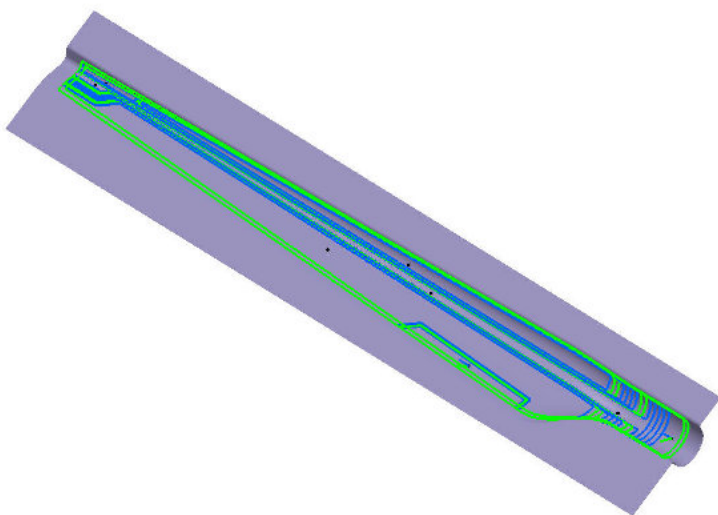
The importance of the digital thread

Ultimately, there needs to be a digital thread from preliminary design to detailed design to manufacturing and quality assurance that ensures a single-source representation of the blade, including the numerous changes as they occur.

This thread provides the ability to quickly assess the impact of design changes throughout the development process. It enables users to understand the ramifications of adding layers of fabric material in order to stiffen parts of the blade, redesigning a drop-off area to extend a few plies or simplifying a mating area to alleviate the presence of a ramp under a shear web.

By establishing this thread, composites engineering software allows the designer and manufacturing engineer to assess the possible consequences of a design change and avoid late conflicts on the shop floor.

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This figure shows an example of the details of a wind blade ply layup. A typical large blade can contain several hundred plies with many different shapes, materials and orientations. Using FiberSIM® composites engineering software from VISTAGY, Inc. to create and modify the layup ensures that no errors are made in the selection of materials, orientations and sequences and that the blade will be manufactured as designed and analyzed. In particular, the use of such advanced design software for composite layup enables a much faster and accurate definition of all drop-off areas in the root, edges and tip areas of the blade. Any design change occurring during the development of the blade design can be readily integrated in the model, allowing rapid assessment and easy propagation to manufacturing.

In addition to the digital thread, technical documentation produced in electronic format should always reference the latest design and be complete enough to efficiently support manufacturing, including all instructions on ply preparation, cutting, layup, infusion, trimming and finishing. Updates to the design should be automatically captured so that engineers will have access to the current version of the manufacturing documentation at all times.

The digital thread should also extend to the supply chain where it is critical to have the ability for two-way communication. In these cases, a common composite engineering environment running across CAD systems will enable rapid and reliable data flow for engineering and manufacturing requirements, specifications and certification documents between partners, suppliers and customers.

At the end of the day, this thread is the tie that binds the entire process and guarantees a firm's ability to deliver high quality wind blades.

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