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HyperWorks Enables Ingeniacity to Reduce Mass of Sailing Yacht Composite Bowsprit by 65 Percent

Ingeniacity

Overview

Designing a very fast and at the same time easy to handle sailing yacht is a very challenging task. The structural design of the hull and all attached parts implies two conflicting objectives, which both have to be met – creating a structure which offers the highest possible stiffness while also being as light as possible. Ingeniacity S.L., a Spanish engineering service provider, was contracted by Juan Yacht Design to analyse and optimize the structural design of a new yacht, a Swan 50 class, and to design a new bowsprit made of composite material. Meeting this challenge required very experienced engineers as well as state-of-the-art simulation and optimization software.

Swan 50 is a cutting-edge sailing class yacht, featuring the latest engineering trends, materials and innovations. One of the most important parts of this structure is the bowsprit, a spar that attaches the forestay forward to the hull. The bowsprit also counteracts the upward tension from the jibs.

To design, analyse and optimize the new bowsprit, the engineers from Ingeniacity applied Altair's HyperWorks suite of computer-aided engineering (CAE) tools. The tools of the HyperWorks suite allow for a streamlined design and optimization process of all materials and is very well suited for composite materials. Thanks to HyperWorks, the Ingeniacity engineers were able to reduce the weight of the bowsprit from its original 54 kg to only 19 kg in the final version – a weight reduction of 65 percent.

"Without a software suite like HyperWorks, the solutions we could have come up with would have appeared to be rather poor and simple. By applying these kinds of optimization tools and processes, it is possible to reach very innovative solutions while saving a tremendous amount of development time," said Ignacio Melón, CAE Engineer at Ingeniacity.

Ignacio Melón,
CAE Engineer at Ingeniacity

Company Profile

Ingeniacity S.L. (www.ingeniacity.com) provides innovative solutions for engineering challenges and develops new ideas and methodologies. Ingeniacity provides its services to many different industries by offering a "problem abstracting" technique that enables Ingeniacity to cover many different applications. Ingeniacity has vast experience in structural design and analysis, applying FEA and CFD techniques, and specializes in the design of composite materials for shipbuilding, automotive, and other industries.

Challenge

The challenge of this project was to reduce the weight of the bowsprit while keeping stiffness properties as high as possible. These conflicting objectives can only be met using composite material and a dedicated optimization technology, applied to the layout of the composite material and the component's shape. The design and optimization of composites presents its own unique challenges because the engineers have to take the characteristics of the material into account to leverage its lightweight and stiffness potential.

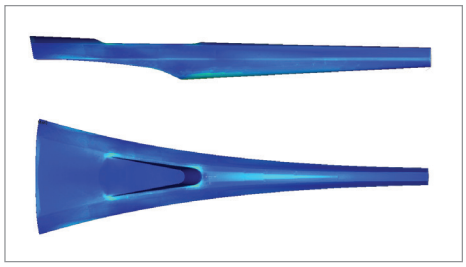
The bowsprit bears the rigging loads and, because the walls are thin to keep the weight as low as possible, buckling modes also have to be considered. In the development process, the engineers therefore had to combine buckling, pretension, and topology optimization to design and optimize the composite part, a method that can lead to very long calculation times by the applied CAE solver. The Ingeniacity engineers had to apply sophisticated CAE tools and optimization technologies which could handle all necessary disciplines sufficiently and do so fast enough to deliver accurate results on a timely basis.

Solution

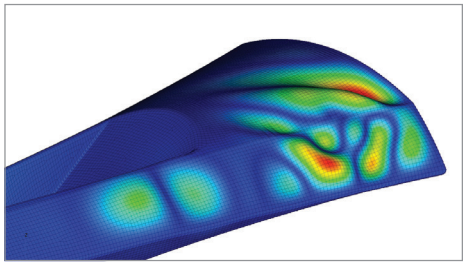
The engineers at Ingeniacity realized very soon that few software tools on the market are suited for this kind of application. Altair's HyperWorks suite provided the necessary tools, particularly HyperMesh for pre-processing and the optimization tool and FE-solver OptiStruct. Thanks to the high meshing quality of HyperMesh, OptiStruct was able to finish this unique use case in about one hour, while other solvers, fed by a different meshing tool, might have taken considerably longer. While the engineers applied various HyperWorks modules, the key tool was the OptiStruct, since it enabled the designers to lighten and stiffen the bowsprit as desired.

Composite design synthesis with OptiStruct allows numerous design variables to be handled in an efficient manner, resulting in truly optimized composite components. This method enables designers to quickly develop a composite design that meets performance and safety specifications. OptiStruct takes a three-step approach: first, the optimal location of ply drops and ply build-ups are determined; second, the ply cut-out patterns are developed; and third, the optimal stacking sequence is defined. Apart from investigating the stacking sequence, the Ingeniacity engineers followed this approach to come up with the best possible solution for the composite-made bowsprit.

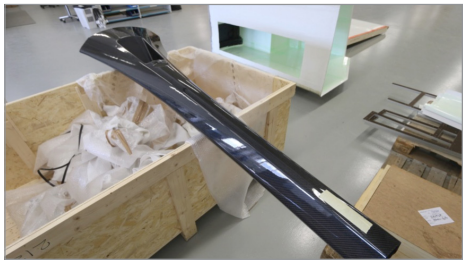
The load cases applied for this optimization had a pretension of 4500 N at the bobstay and more than five tons of weight from the rig at the same time. The pretension manager included in OptiStruct was very helpful when setting up the simulations. Thanks to HyperWorks, the engineers created a new bowsprit design that was 34 kg lighter than the previous model. With a weight of only 19 kg, the final version's bowsprit mass was reduced by almost 65 percent.



Composite failure on the laminate



Buckling on the laminate



Final bowsprit

Benefits

By applying Altair HyperWorks CAE tools and its optimization tool OptiStruct, the Ingeniacity engineers were able to perform high-level simulations without having to go through an expensive physical test stage. The option to change the plies of the laminate, and an easy iteration between different models without having to modify the rest of the model setup, was key to a short and streamlined development process. Since physical testing to iterate the design was never planned, the engineers had to and were able to virtually test the various variants and came up with the best possible result before the first prototype was built.

HyperWorks with its modeling and calculation tools helped the team to:

- Significantly reduce weight while maintaining the required stiffness
- Evaluate various design variants virtually to come up with the best solution
- Save development time and costs

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