FARR YACHT DESIGN

DESIGNER'S VOICE

An inside look at our world of yacht design.

Parametric Design and Engineering of Appendages

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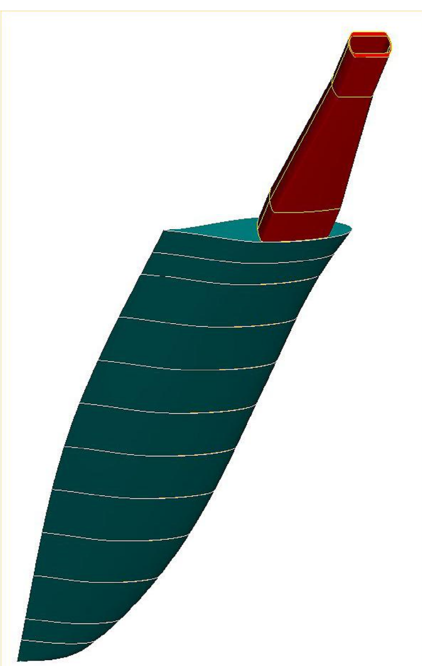
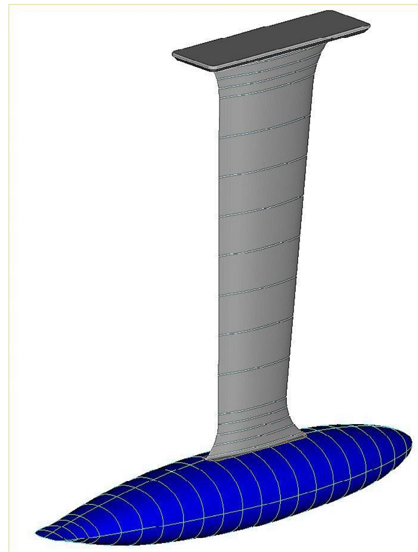
To maintain a competitive technological edge, the team at Farr Yacht Design is continually developing new and unique methodologies for every aspect of our design work. Often this is via developments in the computer software we use for design and analysis. Where possible, we use commercially available software. However, we also devote much time to developing our own software and to developing customized enhancements to the commercially available software that we use. Through this tailored software development, we gain significant capabilities beyond those of our competitors to accurately design and analyze state-of-the-art yachts.

One such area of development is our integrated, detailed design and engineering of appendages such as keels, bulbs, rudders and canards. For designing these parts we use Pro/Engineer, which is a commercially available, high-end parametric modeling software package. Parametric modeling, in general terms, allows the creation of geometric shapes through defined relationships between features. This facilitates the ability to build intelligence into the model such that the relationships between key design parameters are always appropriately maintained. Such relationships often involve detailed mathematical equations that can be programmed into the model to define the character of the geometric shape. Key to the success of a parametric model is the ability to properly establish and then vary these mathematical relationships to fully explore the design space.



Rudder stock and blade model.

As an example, consider a high-performance racing keel (e.g. America's Cup or Volvo Ocean Race). For the fin, we will typically use foil-design software such as XFoil to design the sectional shape. Often the optimum design will vary the sectional shape along the span of the fin. Through a custom-designed spreadsheet we can automatically transfer the foil coordinates from XFoil to Pro/Engineer in a pre-defined format. The model is programmed to receive this data and apply additional inputs such as the span-wise distribution of foil section transitions and the planform definition such that the fin is automatically updated with the correct shape. The result is truly infinite mathematical control over the fin geometry, not a simple blending of a few pre-defined sections. For the bulb, simple input parameters such as length, width, and height are not very useful for developing a complex shape. Of much greater value is to provide as input size- and shape-descriptive parameters such as volume, prismatic coefficient, length/diameter ratio, squish ratio, droop, etc…Developing



"T" shaped keel model for a racing yacht.

parametric models to receive such input and produce the desired geometry results in the ability to create and analyze multiple design iterations very quickly. Similar methodologies apply to the modeling of rudder blades and stocks. Only through extensive custom programming of our parametric models are we able to do this.

Once the geometry has been created, we are then able to utilize the model for hydrodynamic and structural analysis. For hydrodynamic analysis, we use a version of the computational fluid dynamics (CFD) software ICEM CFD that integrates into the Pro/Engineer design software to automate the preparation of the models for analysis. We can then use any one of a number of solvers to analyze the flow around the shape that has been created. Updating the geometric model based on the results of the analysis is then simply a matter of modifying the input parameters to achieve the desired changes.

For structural analysis, we have programmed into the geometric models the equations necessary to calculate stress

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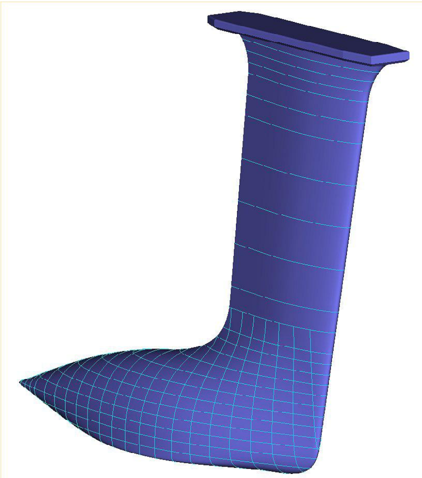
...Appendages continued



Model of an "L"shaped cruising keel.

and deflection of components such as keel fins and composite rudder stocks. The results of these calculations are automatically presented in custom-designed reports. As the designs are evolved and their shapes changed, the structural calculations and the associated reports are automatically updated. In addition to keels and rudders, a recent addition to these structural capabilities is the programming of longitudinal deflection calculations into a model of the hull and deck, which similarly will automatically update as the design evolves. This includes development of laminate composition as well as hull and deck geometry. Often it is not straightforward to develop sets of equations to accurately solve these structural calculations. In most cases we have utilized advanced finite element analysis (FEA) methods to help develop and validate the solutions we are programming into the geometric models.

Once we are satisfied with our designs, both hydrodynamically and structurally, the parametric models are then expanded to include any necessary production details and utilized as the basis for our detail drawings, for which we use Autocad. In addition, we can also provide three-dimensional surface models to the manufacturer from which the parts can be directly milled to the final shape, or moulds can be created.

The ability to customize our design software to automate the shape creation, hydrodynamic analysis and structural analysis of appendages has been a significant enhancement to our design process. It is important to note that this system is utilized for every one of our designs, not just high-profile race boats. More than five years in the works, we now have parametric models of nine different styles of keels and three types of rudder blade/stock. Beyond appendages, we have also developed extensive parametric modeling capabilities for deck geometry, internal structure and even detailed parts such as chainplates, forestay fittings and backstay fittings. This integration of the design and engineering of the major components of the yacht greatly enhances our ability to produce world-class designs.