Ship Energy Performance Framework

Case Study: Optimization of Hull Lines of a Newbuilding Chemical Tanker

Tier 3: Improvement Investigation

CASE

An owner contracted a newbuilding chemical tanker of approximately 20k dwt and requested ABS to cooperate with the builder to improve the design's propulsion energy efficiency. The builder first designed an initial hull geometry. The owner provided an operational profile for the vessel, i.e., the percentages of time the vessel would operate at certain speed-draft combinations. ABS' role was to improve the vessel's "overall" hydrodynamic efficiency by means of computational fluid dynamics (CFD)-based optimization.

METHODOLOGY

ABS took the builder-provided hull geometry model as the baseline model for optimization. The geometry model was first parameterized into more than 20 control parameters, which together could represent the geometry of the hull. The variation of the hull geometry would be made through those control parameters. This parametric model was compared to the baseline hull to make sure their hydrostatic parameters closely matched. A stock propeller with key parameters close to the original propeller was selected, and the open-water performance curves were calculated using propeller analysis tools. For CFD simulation, ABS applied the in-house CFD tool and simulation procedure to model the existing hull, appendages and propeller for self-propulsion simulations. The optimization goal was to minimize the weighted average delivered power over the given operational profile. The search for the optimal hull consisted of two stages. The first stage depended on a population-based screening method. The second round of search applied the Genetic Algorithm, more focused on the promising subspace. With thousands of candidate geometries evaluated, the hull that achieved the minimal delivered power was identified. In the last step, the speed-power curves of the optimized hull were obtained and compared with those of the baseline (original) hull to confirm the gain in energy efficiency.

The final comparison showed that the hull form optimization achieved a 2 percent reduction in the weighted average delivered power over the entire operational profile. This improvement was on top of the baseline hull, which had already been optimized by the builder.

DELIVERABLES

- The three-dimensional geometry model for the optimized hull.
- The comparison of the speed-power curves between the original and the optimized hull.
- Graphical output about the hull pressure distributions on the hull surface, free surface patterns about the hull and wake distributions forward of the propeller plane.

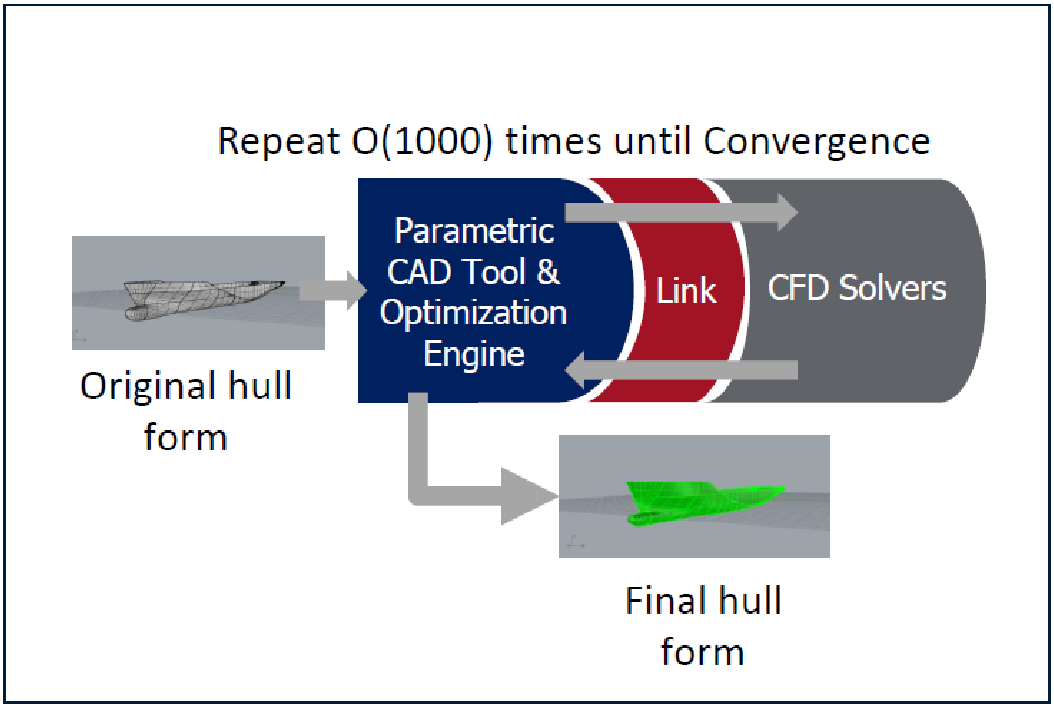

Figure 1: The general process of CFD hull form optimization.

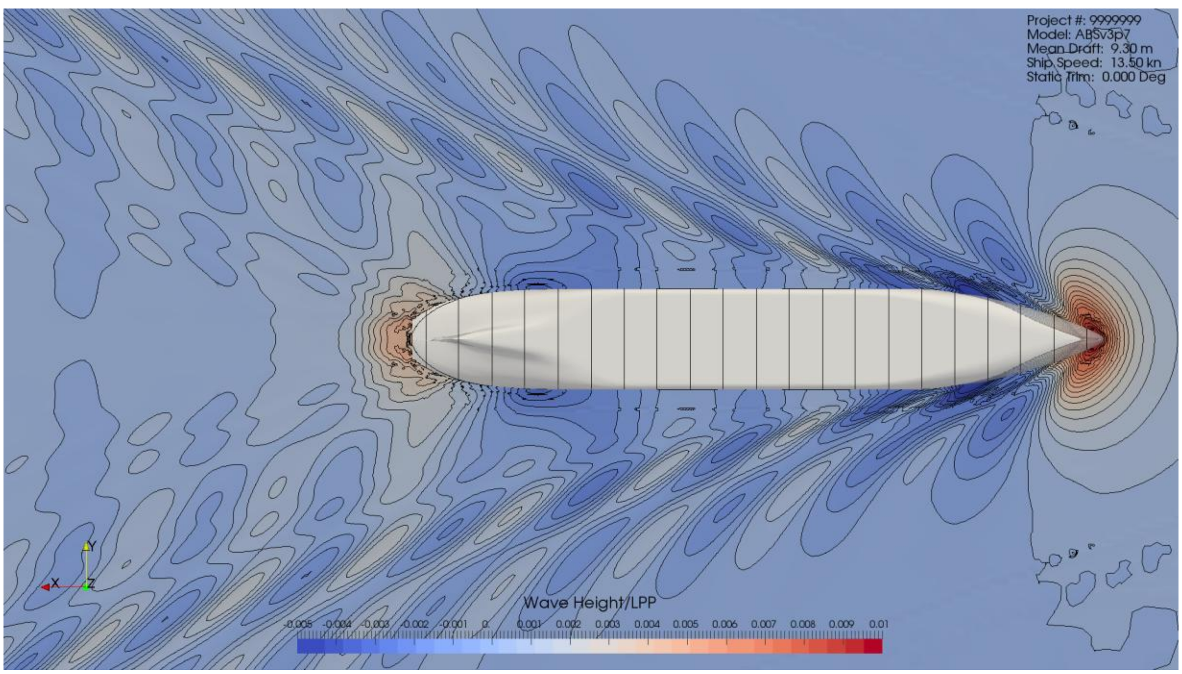

Figure 2: Sample free surface pattern from CFD simulation.

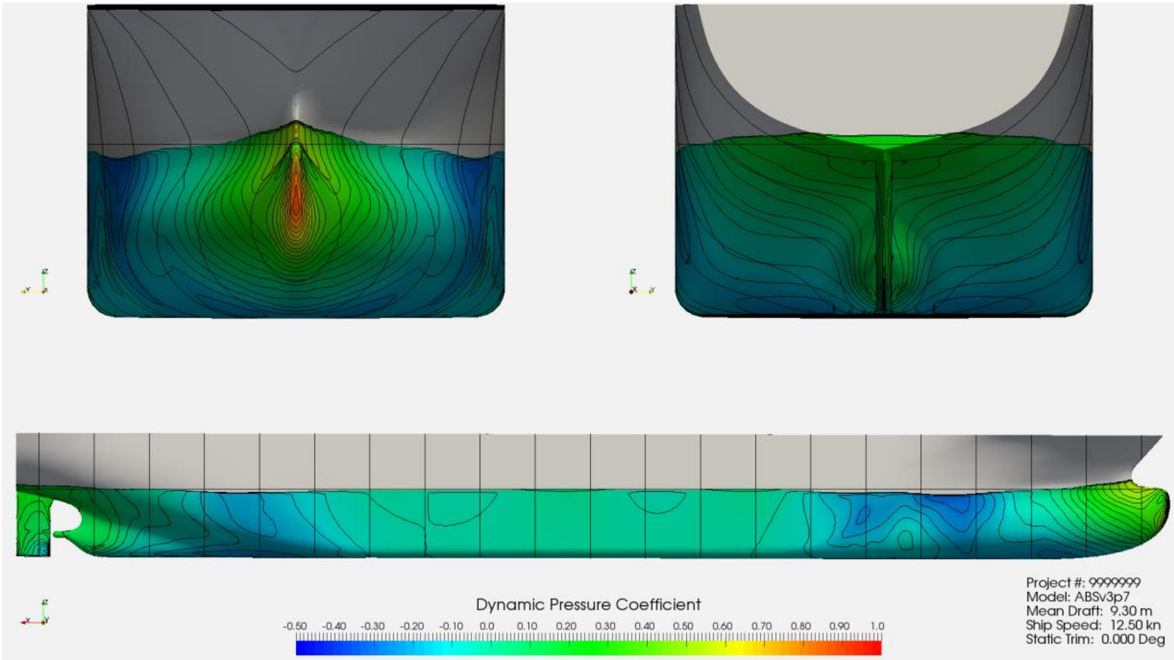

Figure 3: Sample pressure distribution over the hull surface from CFD simulation.

CONCLUSION AND RECOMMENDATIONS

- Hull lines optimization requires in-depth knowledge, as such projects have commercial ramifications.
- The complexity of extracting practical information from a CFD solution should not be underestimated. A single simulation can generate tens of millions of data points. The user needs to be intimately familiar with detail-oriented, state-of-the-art technology and simultaneously sensitive to broader issues such as performance, regulations and customer satisfaction.
- Improvement of hull lines at the design stage for the operating profile of a vessel is prudent as all parties, designer-builder and owner-charterer, can reap the benefits of an energy-efficient vessel.

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