HYDRODYNAMIC HULL OPTIMIZATION SAVES APL $30 MILLION A YEAR

COSMIN CIORTAN
DNV (now DNV GL)

In connection with an order of a series of 10 new 13,800 TEU container vessels from the world's largest shipbuilding company Hyundai Heavy Industries (HHI), the global container transportation company APL requested DNV Maritime Advisory to cooperate with the shipyard to ensure superior hull efficiency of the vessels.

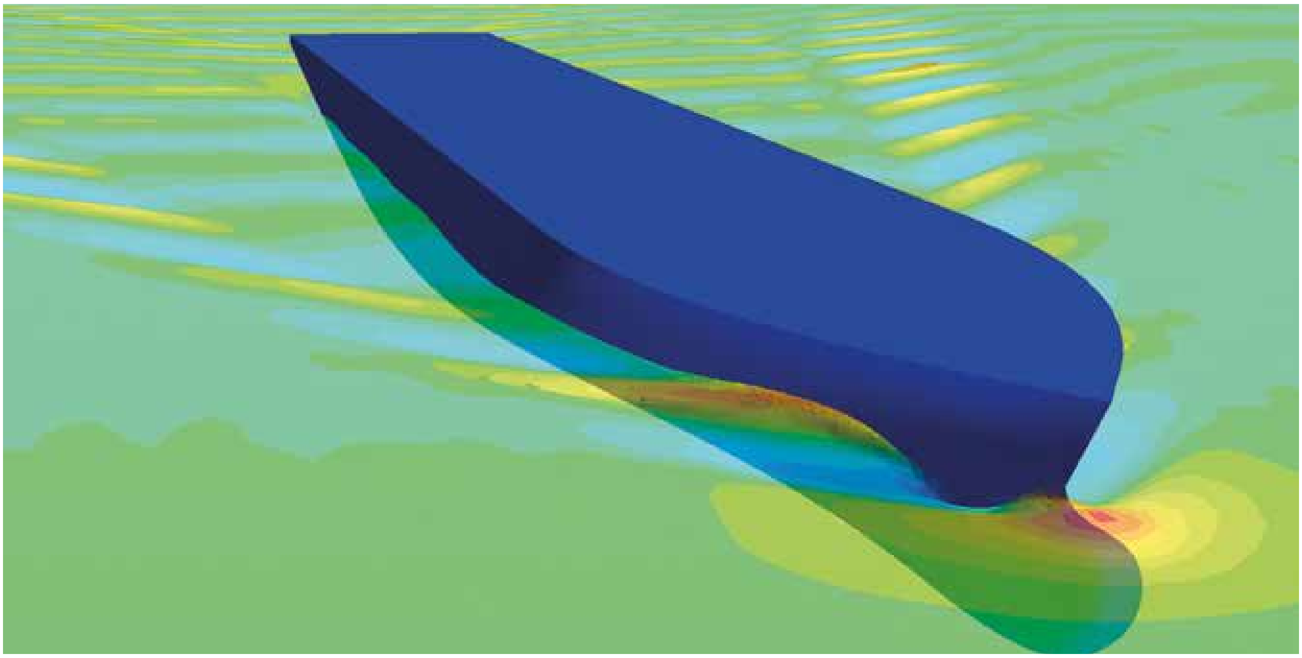

FIGURE 1 - Visualization of the simulation results for a draft/speed condition of 13 m/19 knots (image courtesy of DNV)

OPTIMIZING THE HYDRODYNAMIC PERFORMANCE OF A VESSEL

Ships used to be optimized for the design point (i.e. to give the best performance at the design draft and speed); however, the ship seldom sails in that condition. As a result, APL asked for a different kind of optimization to be performed, this time targeting various speed-draft combinations as described in the operating profile.

APL Director Shaj U. Thayil, who was in contact with DNV and knew of their innovative, energy-efficient container ship concept Quantum, says: “We got our inspiration and ideas from Quantum. Together with DNV and Hyundai, we analyzed the traffic and operation pattern we would use the vessels for. We set up nine focus criteria. The goal was to achieve a 30% overall improvement in energy efficiency. We achieved a 36% improvement.”

The overall hydrodynamic performance of a vessel is directly connected to the resistance and propulsive efficiency. The resistance is influenced by the hull shape, the wetted surface area and the configuration of appendages, while the propulsive efficiency is influenced by the propeller open water characteristics and the interaction between hull and propeller. The performance depends on the variation of operating conditions, i.e. vessel speed, draft and trim.

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Vessels have traditionally been optimized for a single condition, normally the contract speed at design draft. With the help of state-of-the-art Computational Fluid Dynamics (CFD) tools and modern computers it is now possible to optimize a vessel for various conditions in which the vessel will be trading.

DNV Maritime Advisory has worked with hull optimization for several years, serving ship owners, shipyards and designers with valuable advice during the design process. DNV’s experts have extensive relevant experience within ship hydrodynamics and energy efficiency, applied to numerous vessel types and sizes including the major segments: tankers, bulk carriers and container vessels.

THE OPTIMIZATION PROCESS

A typical project for hydrodynamic hull optimization may include:

- Establishing a close dialog between DNV, the ship owner and the shipyard;
- Defining a realistic operating profile;
- Discussing and combining DNV’s design ideas with the yard’s design philosophy to obtain an optimal hull in both a hydrodynamic and building perspective;
- Optimizing the hull forebody based on the operating profile;
- Optimizing the hull aftbody to improve the propulsive efficiency, including consideration on propeller and machinery configuration;
- Assessing the Energy Efficient Design Index (EEDI);
- Supporting during preparation and attending the towing tank model tests.

The delivered value for the ship owner and the shipyard is increased confidence in the hydrodynamic performance of the hull. Typically, considerably improved fuel efficiency and reduced gas emissions are achieved throughout the vessel’s lifetime.

In this specific case, the scope of our work included:

- Establishing a weighing matrix for the vessel’s relevant operating profile;

- Optimizing the hull forebody and aftbody (shoulders, bulb, transom stern height, etc.) based on the operating profile;
- Analyzing the wake and propulsion efficiency;
- Predicting the speed – power and fuel oil consumption curves;
- Assessing the preliminary EEDI;
- Attending the towing tank model tests.

All simulations of resistance and wake assessment were performed using STAR-CCM+®. According to Olav Rognebakke, head of ship hydrodynamics and stability at DNV, it is the availability of powerful CFD tools such as STAR-CCM+, combined with the expertise of highly qualified staff which made it possible to enhance Hyundai's already very good design: "The optimization process is based on heavy CFD calculations," says Rognebakke. "In the past, DNV could not have performed such heavy computations so quickly and at such an affordable price."

"CFD is like a virtual towing tank", says Tor Svensen, president of DNV, who like Rognebakke has a PhD in hydrodynamics. "We can make as many modifications and adjustments as necessary and immediately see which consequences it will have on other areas of the design," adds Rognebakke. Once the design of the new hulls was completed, Hyundai tested them in their towing tank. "The virtual towing tank does not replace testing in the ship model basin, but it means that we can get much better models for the testing," says Rognebakke.

OUTCOME OF THE ASSESSMENT

The hull was optimized for 5 different design points (different speed-draft combinations). The aft part was optimized for maximum propeller efficiency. In addition, the bulb was lowered in order to be efficient at lower drafts too. While this solution may result in a marginal penalty at the original design condition, the aim was to optimize the hull for a range of operating conditions. Instead of a design speed of 25 knots, the new vessels were optimized for lower speeds, with a top speed of 23 knots, following the "slow steaming" trend observed in the last years: "The hull was optimized for the speed range the ship will mainly operate in, i.e. between 15 and 19.5 knots," says Tor Svensen.

All in all, the overall improvement in energy efficiency was 36%:

"We can make as many modifications and adjustments as necessary and immediately see which consequences it will have on other areas of the design,"

"The ships can still carry as many containers as before, but are 36 percent more energy-efficient, said APL director Thayil, satisfied. "In addition to saving fuel costs, it is a positive environmental message."

CONCLUSION

By working closely and keeping a continuous dialogue with APL and HHI, DNV ensured that the best ideas and results were combined into the final hull design. It was estimated that the optimized hull will result in annual fuel savings of about USD 3 million per ship, which amounts to annual savings of USD 30 million for the whole fleet. These achievements provided positive market attention and ensured improved market positions for both the ship owner and the shipyard. Finally, the cost of the service provided by DNV Maritime Advisory is negligible compared with the savings achievable through improved fuel efficiency. DNV, which is an independent foundation, has entrusted all commercial rights to Hyundai Heavy Industries.

FACTS

DNV Maritime Advisory runs fully viscous and potential flow CFD simulations at full scale. STAR-CCM+ and Shipflow are used on a computational cluster with more than 600 CPUs. Several design applications are used, including MaxSurf, NAPA, Rhinoceros, HDef and ShipX.

DNV has been carrying out hydrodynamics hull optimization projects in cooperation with major ship owners, world leading shipyards and design offices. Previous projects covered several container vessels ranging from 1,600 to 14,000 TEU, Aframax and Suezmax tankers, bulk carriers ranging from 38,000 to 206,000 DWT and offshore supply vessels.

ACKNOWLEDGEMENTS

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FIGURE 2 - New hull design (image courtesy of DNV)

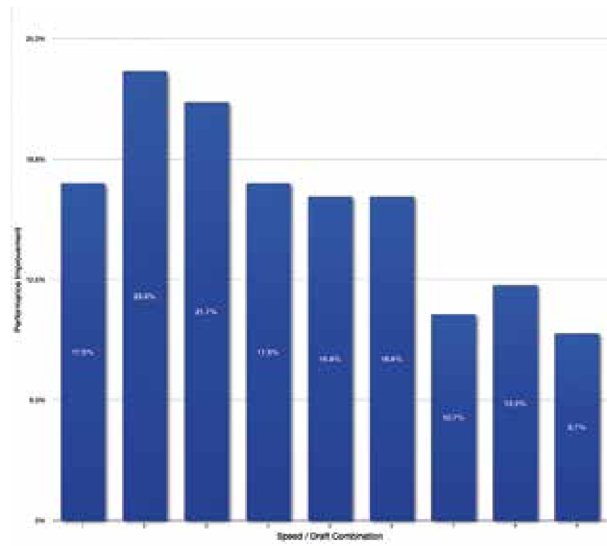

FIGURE3 - Hull performance improvements for different draft-speed conditions (image courtesy of DNV)

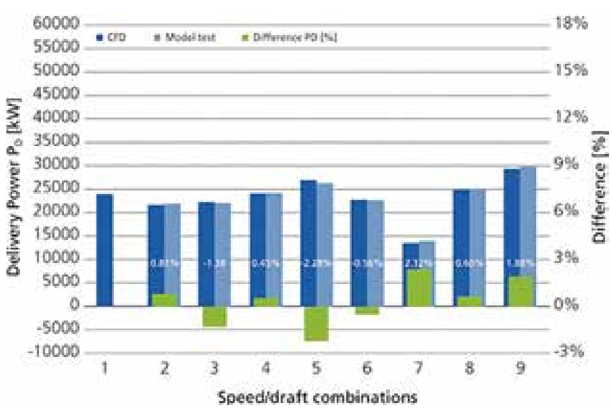

FIGURE 4 - Comparison between the CFD analysis and model tests (image courtesy of DNV)

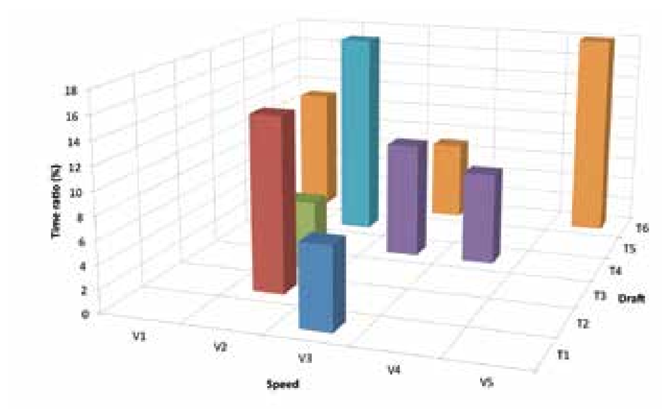

FIGURE 5 - Example of an operating profile (image courtesy of DNV)

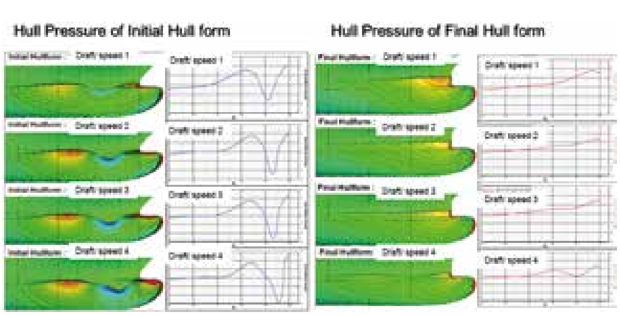

FIGURE 6 - Distribution of hull pressure in the initial and final hull forms (image courtesy of DNV)

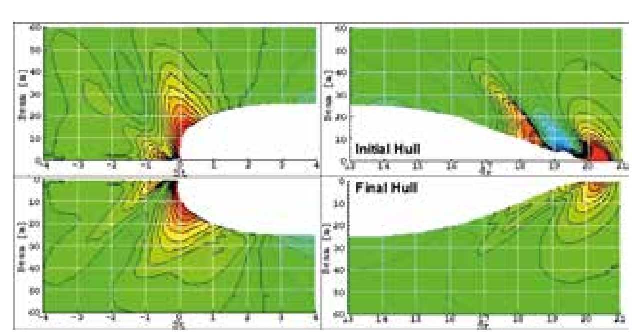

FIGURE 7 - Visualization of calculated wave pattern (image courtesy of DNV)