CD-adapco has a 25-year history of providing state-of-the-art flow, thermal and stress simulation to the marine industry. From large shipyards to suppliers of small components, the use of our technology has become a standard feature in marine design and safety assurance process. Using our cutting-edge solver technology, our customers have been able to tackle some of the most demanding problems that the industry has to offer. Recent successes include:

**Bow Flare Slamming**

Bow flare slamming is caused by the extreme pitch-and-heave motion of a ship operating in rough seas. Modern ultra-large container ships, which typically rely on the additional cargo capacity of a large bow flare, are often exposed to a high risk of slamming due to their relatively high speed and operational requirements that they be driven through adverse weather conditions.

CD-adapco’s simulation technology has been used extensively throughout the industry to understand the mechanisms behind bow flare slamming and to help mitigate the risk of damage. A significant advantage of numerical simulation is that tests can be carried out at full scale and that pressure loads can be predicted at every point on the hull.

In the example shown here, courtesy of Germanischer Lloyd, a commercial super-liner is subjected to waves of 7.3 meters height, while travelling at 26 knots. A graphical comparison of the pressure experienced at various points on the hull surface shows outstanding agreement between numerical and experimental studies. The overall quality of the simulation results gave Germanischer Lloyd’s engineers confidence in the methodology, enabling them to assess the safety of a wide range of ship designs, operating under the most adverse conditions.
Pitch and roll simulations
The motion of a vessel under the influence of a rough sea is a complex combination of translation, pitching, rolling and yawing. CD-adapco’s simulation technology allows the motion of a vessel to be predicted in all six-degrees of freedom, using a fully coupled simulation technique that accounts for both the influence of the flow on the boat, and the influence of the boat motion on the flow.

Germanischer Lloyd have used this technology to good effect in their analysis of the unconventional Earthrace vessel (which is currently circum-navigating the world: www.earthrace.net - see photo overleaf). In rough conditions the Earthrace boat is designed to pierce through waves instead of riding over them. In the results shown below, the bow of the boat can be seen entering a simulated wave. Simulation results such as these allowed the boat designers to understand its performance in very rough conditions, from the comfort of their design-studio, before even the first prototype had been built.

Propeller and rudder cavitation
Cavitation is a significant cause of damage to ship propellers and rudders, often causing surface pitting and fatigue-inducing vibration. CD-adapco’s simulation technology accurately predicts the onset of cavitation and the unsteady phenomena associated with the build up and break up of large cavitation regions. Detailed analysis of both steady and unsteady cavitation has been performed with considerable success across the industry. In the example shown, courtesy of Germanischer Lloyd, the areas in gray indicate a vapor content of above 10%, showing the presence of large cavitation bubbles. For a given design, this technology allows designers to identify under which operating conditions the worst cavitation problems are likely to occur, or alternatively which design is least prone to cavitation under a given operating condition.

Structural deformations from wave impact
Slamming loads can cause deformation of local structural components and induce high stresses. The accurate assessment of such loads is essential for the design of a ship’s structure. Classification society rules contain formulas for slamming loads. Generally, these formulas are adequate for conventional ships, as they are based on operational experience. However, for many modern ships it becomes necessary to resort to direct computations of slamming loads.

In an extension of the work described above, deformation of the ship’s structure resulting from the impact of a series of large waves was predicted. In a coupled fluid-structure-interaction simulation the forces calculated from the simulation of the flow were used (via an interface developed by Germanischer Lloyd) to provide boundary conditions for a structural-analysis simulation, which predicted the structural deformation as shown.

For more information on the simulations mentioned above, and further applications of CD-adapco software, contact CD-adapco or the CFD team at Germanischer Lloyd.

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