non-ferrous, and fiberglass hulls and to deploy various sensors makes the HullBUG the best choice to overcome the numerous challenges involved in inspection and grooming. Opportunities in commercial shipping, oil and gas, nuclear, and conventional power generation markets are under discussion.

SeaRobotics specializes in small, smart vehicles that are remotely or autonomously operated. Its clients include major military and commercial organizations, both U.S. and foreign. SeaRobotics' marine survey software interfaces with most data acquisition hardware, software, and sensing systems to produce multi-spectral, DGPS-stamped data for survey, research, or surveillance efforts. Applications for SeaRobotics vehicles range from hull grooming and inspection to bathymetric and hydrographic surveys to coastal, harbor, and riverine surveillance. Many SeaRobotics vehicles are small, modular, and man-portable, allowing for rapid deployment in remote areas.

Source: www.searobotics.com

Advanced Simulation Helps to Solve Ballast Water Management Problems

Tobias Zorn, Jan Kaufmann, FutureShip & Milovan Peric

Ballast water management poses problems in design and operation of ships. Computational fluid dynamics (CFD) offers solutions with design, type approval and trouble-shooting.

Computational fluid dynamics (CFD) denotes collectively techniques for solving equations describing the physics of fluid flow. CFD is by now widely known and accepted in the maritime industry, but mostly associated with flows around the hull and propellers, for example in the context of designing more fuel-efficient ships. However, CFD is in many ways far more versatile than classical model testing.

The same software can be applied to a variety of flows, including also internal flow problems.

A key advantage of CFD is the insight into flow details. As flow quantities are computed (and stored) at many discrete locations in space (computational cells) and for many time steps, it is easy in post-processing to look at arbitrary cross-sections and zoom in and out at will.

Ballast water management systems have moved into the spotlight for ship operators with recent IMO regulations which drive the transition towards ballast water management to curb the spread of invasive species. But apart from the particularities of the new regulations, ballast water handling may pose challenges for ship operators where the advantages of CFD simulations come into play. The following case studies illustrate problems and solutions taken from industry experience.

Case study 1: Type approval based on CFD

The ballast water of ships carries plants and animals which frequently settle in foreign sea regions, representing a danger for the indigenous aquatic environment, potentially causing great ecological, health-related and economic damage. The growing ship traffic has increased this threat considerably. The IMO "International Convention for the Control and Management of Ships' Ballast Water and Sediments" requires a ballast water management plan. Starting from the year 2016, all ships will have to base their ballast water management on ballast water treatment.

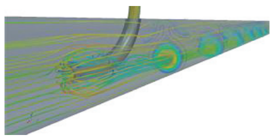

Figure 1.
CFD simulates mixing of two fluids in a pipe for type approval.

If this treatment is based on chemical approaches, rapid and effective mixing of the chemical component with the ballast water is vital to achieve a homogeneous concentration of the biocide. For type approval of new systems, simulations can be a valuable tool. In one case, FutureShip simulated the mixing of chlorine and ballast water in pipes during the ballasting operation. The CFD simulations were used to determine the required pipe length of the mixing zone to ensure homogeneous mixing. Simulations showed that the mixing in the initial design was inefficient. Very simple and cost effective modifications of the inlet geometry served to increase the turbulence level significantly with a resulting much shorter pipe length for complete mixing. Figure 1 shows compute streamlines and chlorine concentration in the mixing pipe resulting from one such simulation. The authorities accepted the simulations as engineering proof for type approval.

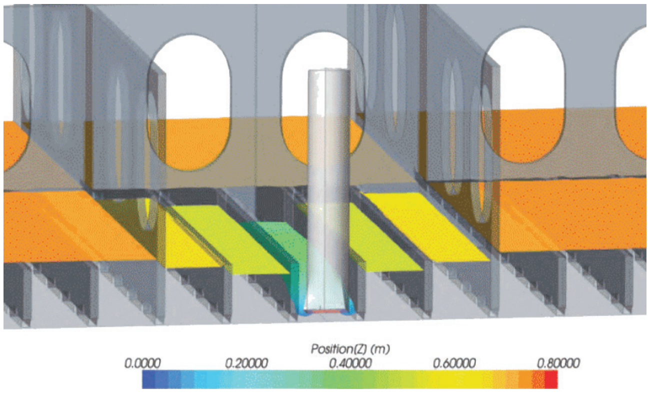

Figure 2. Snapshot of de-ballasting simulation reveal uneven water levels due to insufficient size of cut-outs (pump intake section is almost depleted).

Case study 2: Ballast water sediments

Sediments tend to collect in ballast water tanks. They reduce the deadweight (payload), restrict water flow thus delaying de-ballasting, and increase draft resulting in higher fuel consumption. For a Capesize bulk carrier, the ship owner wanted to reduce sediment accumulation and tasked FutureShip with detailed analyses and suggestions for re-design in order to minimize sediment settling in the ballast tanks.

In this case, the actual sediments were not modeled. Instead, engineering insight facilitates the simulation. Sediments settle in regions of low water speed, as found typically in areas of recirculation and flow stagnation; these are commonly referred to as dead-water regions. Figure 2 shows sediments in a real ballast water tank. The two-phase (water and air) simulations of flow in ballast tanks first identified dead-water areas corresponding to observed sediment accumulation in the original design. Figure 3 shows computed velocity distribution near bottom wall. Then various design alternatives for the ballast water tanks explored variations of stiffener spacing and cut-outs. The simulations identified the alternative design with least sediment settling (i.e. smallest dead-water regions) for future bulk carrier orders.

Case study 3: Ballast water de-ballasting

A busy coal terminal in Latin America had given strict time limits to de-ballast a bulk carrier at quay. The ballast pump was taking in air during de-ballasting, forcing the crew to stop de-ballasting intermittently. As a consequence, the vessel could not be de-ballasted in the time given by the terminal. The vessel had to leave with 3000 t of ballast water still in the tanks. As a consequence,

Figure 3. Sediments accumulate in ballast water tanks in areas with flow stagnation.

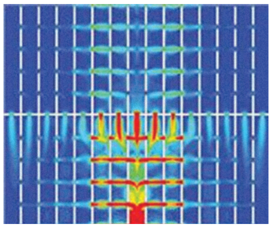

Figure 4. CFD simulation of velocity distribution in ballast water tank close to bottom wall.

2600 t of cargo could not be loaded, resulting in 125,000€ damage claims and the vessel being blacklisted at the terminal.

A detailed analysis is often the first step in trouble-shooting. Once the problem has become transparent, the solution is straight-forward. In this case, the first step was thus to simulate the de-ballasting process, setting up a three-dimensional model of the ballast water tanks and mimicking the pump by a prescribed flow rate at the outlet of suction pipe. The out flux was set to the maximum pump capacity. The simulation of the two-phase flow revealed that the water level in neighboring fields was much higher than in the field with the ballast pump intake during de-ballasting. Figure 4 shows the uneven water levels in various tanks sections. The size of the water-flow openings in the longitudinal frames was too small for de-ballasting rate of the pumps. The simulation provides information about the time-dependent flow rate through each opening and predicts the time at which air begins to be sucked by the pump. The animation of free surface motion and velocity distribution in various cross-sections gives engineers a direct insight into the physics of the flow and allows an easy assessment of the problem, aiding the design of necessary geometrical modifications. Based on the analysis of simulation data, more and larger water-flow openings for the frames in the vicinity of the pump were suggested to synchronize fluxes through openings with the pump intake flux. Size and location of the water-flow openings could then be determined such that the inflow toward the pump was above the pump rate, thus avoiding the risk of the pump taking air.

Conclusion

CFD simulations have proven to be a versatile and powerful tool to support design and operation of ballast water management systems. The combination of advanced computational software and expert users yields detailed insight and reliable answers.

Acknowledgements

The authors appreciate the help and cooperation of their colleagues Volker Bertram and Jan Rüde.

CFD method

The simulation employed CD-adapco's CFD software STAR-CCM+. This software is capable to simulate turbulent flow with resulting eddy formation and turbulent mixing, as well as multiple fluids with resolved liquid-gas interfaces. It is thus able to capture all important physics for the analysis of ballast water flows as presented here. The solution method is based on conservation equations in integral form with appropriate initial and boundary conditions.

The solution domain is subdivided into a finite number of control volumes which can be of an arbitrary polyhedral shape and are typically locally refined in regions of rapid variation of flow variables. The time interval of interest is also subdivided into time steps of appropriate size. The governing equations contain surface and volume integrals, as well as time and space derivatives. These are approximated for each control volume and time level using suitable finite approximations, leading to an algebraic equation system which can be solved efficiently on a multi-processor computer.

The flow is assumed to be governed by the Reynolds-averaged Navier-Stokes equations. Turbulence effects can be accounted for by a variety of models, from the simplest eddy-viscosity type models (k-[] or k-[] models are typically used) up to the Reynolds-stress models. Thus, the continuity equation, momentum equation, and between two and seven equations for turbulence properties are solved. Large-eddy simulations, which model only the small-scale turbulence and resolve large-scale eddies, are also possible.

Multi-phase, multi-component systems (water-air or water-chlorine in the applications shown here) can also be simulated. The spatial distribution of the phases (liquid and gas) is obtained by solving an additional transport equation for the volume fraction of each additional phase. To accurately simulate the convective transport of immiscible fluids, the discretization must be nearly free of numerical diffusion.

For this purpose, a special high-resolution interface-capturing (HRIC) scheme is used, providing a sharp resolution of free surfaces and allowing simulation of flow with trapped gas bubbles in liquid or liquid blobs in gas.

Reprinted with permission from Maritime Reporter.

Seafarers' Evening- 61st Anniversary

Jadran Marinković (Head of Radio Show)

Figure 1. Editor Jadran Marinković.

Pomorska večer (engl. *Seafarers' Evening*), a programme about sea and the people related to the sea, especially intended for seafarers and their families, is one of the oldest programmes of the Croatian Radio. For the first time, entitled as A PROGRAMME FOR SEAFARERS, it was transmitted on July, 8th 1952, so this year has been the 61st anniversary of its continuous transmission every Monday. It used to last for an hour, then two hours, and currently it is transmitted from 20.15 hours till midnight‡and from 5 "maritime" radio stations of the Croatian radio: Pula, Dubrovnik, Rijeka, Zadar and Split.

In the period of Morse symbols, without satellite navigation, mobile phone or Internet

the programme was a link to the distant seas and oceans via medium and short waves of the Croatian Radio. Greetings and messages, news from the homeland, proceeding of the vessels used to be a kind of challenge to the listeners, not only at sea, but also on the continent and Croatian emigrants.

The programme that has been with us for more than 60 years sticks to the rule "*with the taste of the sea, with the taste of the salt*" – regarding not only the stories and coverages, but also our distinctive music. There is a small number of even larger maritime countries with this type of a specialized programme dealing with all important topics from the field of maritime affairs, fishing, shipbuilding, port operations, safety of navigation. In numerous coverages, meetings, notes, severe comments and public warnings the programme editors have always strived to take the side of the seafarers, fisherfolk and dockers wishing for the things to get better and gain more success as the sea and vessels have always been a source of living.

Seafarers' Evening, which has already become a cult, every Monday wishes to convince both the general public, but especially those involved in politics that Croatia should be a MARITIME and not only a COASTAL country, some 20,000 seafarers the majority of whom unfortunately man foreign vessels not being the only reason.