Roll-damping tank analysis and engineering services with a six-DOF motion platform

HEXAPOD SERVICES Hoppe Marine GmbH, an international specialist for anti-rolling tank systems, designs and outfits vessels with different passive damping systems. Having invested in new technologies, using a six-degree-of-freedom (DOF) hexapod and a high precision measurement system with minimum latency, the family-owned company is developing roll-damping tank designs for the future.

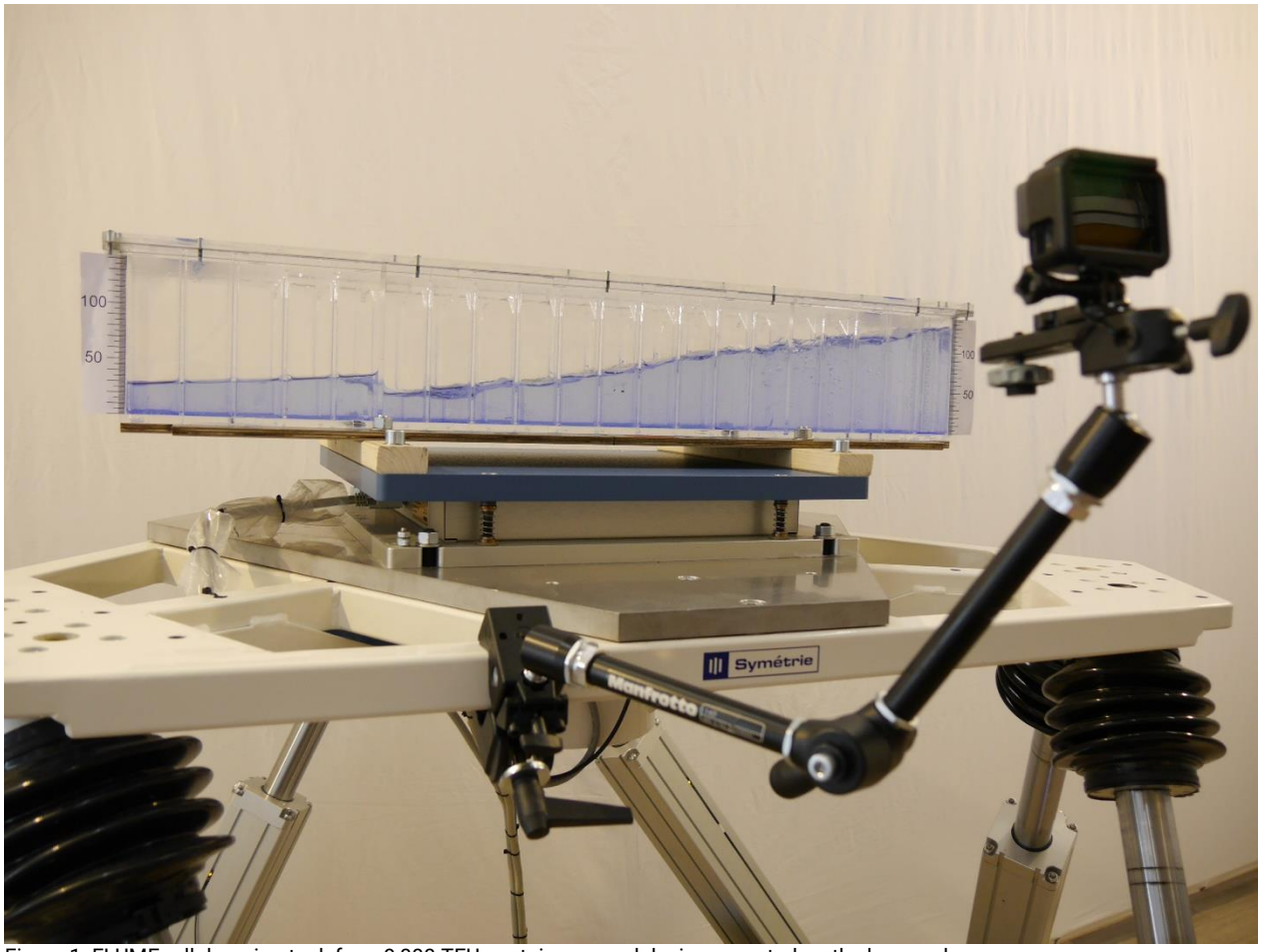

Figure 1: FLUME roll damping tank for a 9,000 TEU container vessel design mounted on the hexapod

To approach clients with attractive concepts reducing operational costs, Hoppe decided to invest in the development of its analysis methodologies used for roll-damping tanks and started one of the biggest research projects in the company's history together with university and industrial partners, in 2016. The joint research project HERMes is conducted by the Hamburg University of Technology (TUHH), the Hamburg Test Model basin – Hamburgische Schiffbau-Versuchsanstalt GmbH (HSVA), Peter Döhle Schiffahrts-KG and Hoppe Bordmesstechnik GmbH. The project is financially supported by the German Federal Ministry for Economic Affairs and Energy (BMWi). As the first major step of this project, the testing facility has been completely renewed with a six DOF motion platform and a six DOF force measurement system in combination with resistance measurement probes (wave

gauges) placed at different positions in the tank model. While in the past Hoppe conducted more than 2,500 model tests with a self-constructed bench, this setup helps the experts analyzing the force and moment response of an object to any given motion, with higher precision and accuracy. Usually the test object is not a rigid body, but contains liquid, e.g., (moon-) pools, (LNG) cargo, sloshing or roll damping tanks. In such an analysis, models of tanks or other compartments are moved with realistic vessel motions. The simulated motion, the water elevation measured at different wave gauge locations and the force measurement are all synchronized, to detect the phase offsets between excitation and different responses. This approach provides a detailed insight into the phenomena of roll damping and sloshing tanks, making the application predictable and fail-safe.

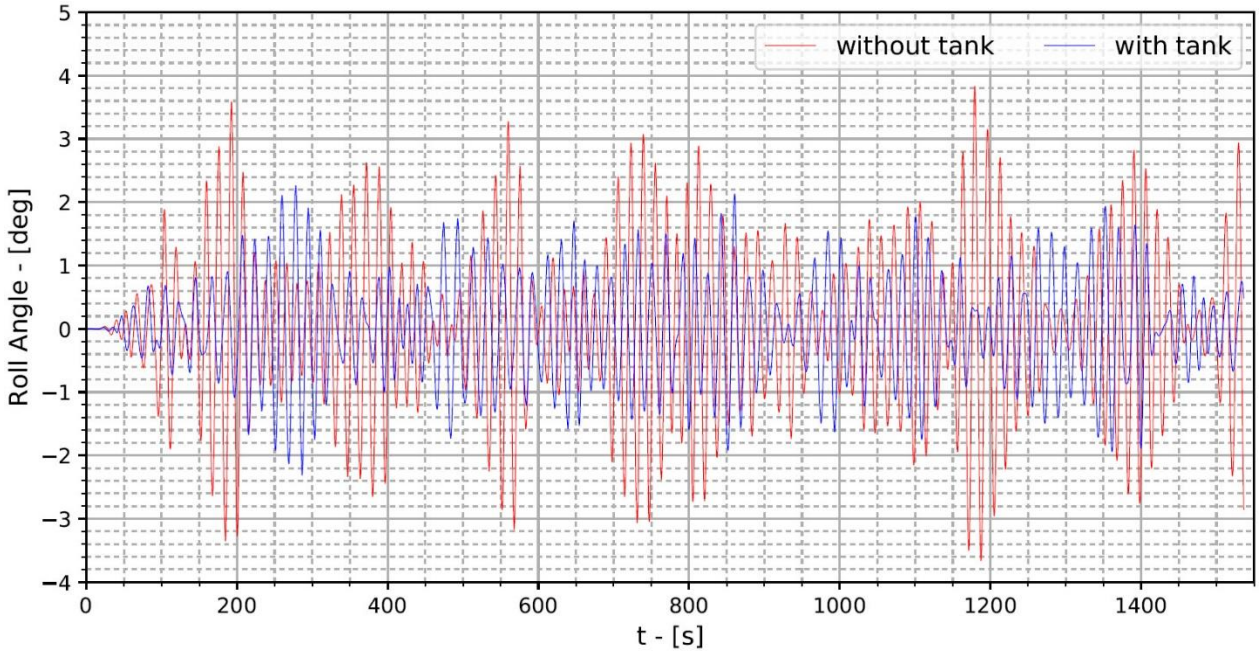

Figure 2: Time domain analysis showing the influence of a FLUME tank on the roll motion of a 9,000 TEU container vessel

Based on the analyzed data, Hoppe can provide its clients results of motion and force trajectories for ships with and without FLUME (free surface tank) or INTERING (U-tank) tanks. The reaction and behavior of the ship is simulated using a numerical model. The advantage of such a numerical model is that the motion pattern can be repeated exactly, hence it is guaranteed that the same conditions are compared with each other.

Furthermore, the results gained from the model tests are transferred into a frequency domain, allowing a simplified study which still takes non-linearities into account, but allows a much more general analysis of the vessel characteristics in different sea states, headings, vessel speeds and load cases.

Such an analysis is required to understand the influence of the tank throughout all possible scenarios a vessel might face in operation. If the hydrodynamic coefficients and the vessel mass and inertia are well known from seakeeping model tests or numerical analysis, this simplified approach gives good results because the nonlinearity of the vessel hull damping and roll-damping tank are taken into account. This has been proven in research where the motion of a harmonic excited ship model at HSVA was analysed, with and without having a FLUME roll-damping tank installed. When the roll-damping tank had not been installed on the vessel model, the FLUME tank was added afterwards numerically using the frequency domain results from the hexapod tests. The results gained from that comparison demonstrated a good correlation between the different approaches.

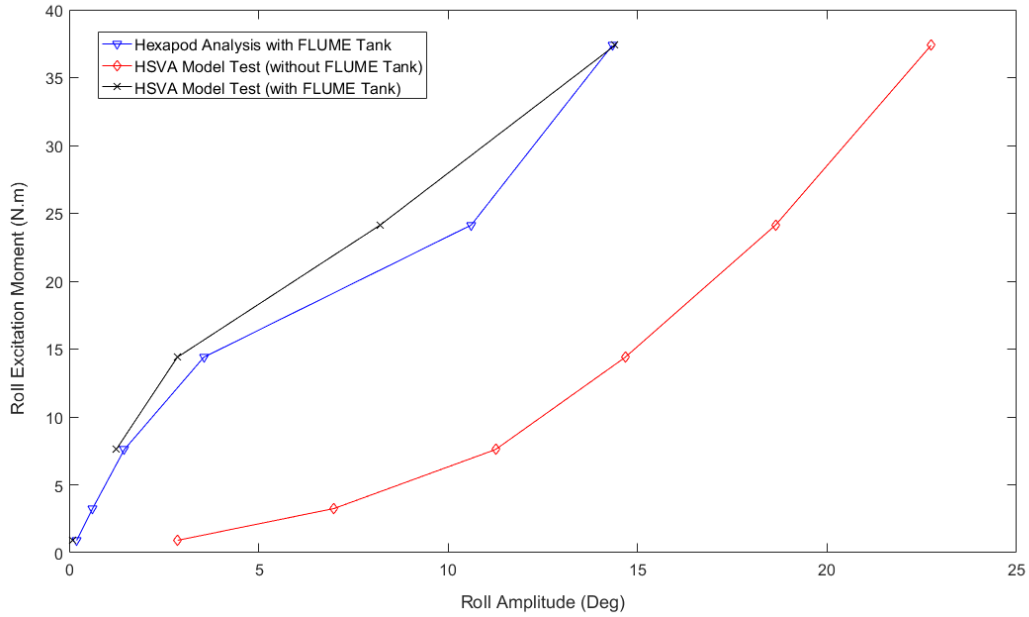

Figure 3: Comparison between experiment using a FLUME tank directly with the ship model and the method in which the FLUME tank Hexapod test results are added numerically to vessel motions without a tank

Today, accurate estimations of roll-damping tank capabilities are accepted by several leading classification societies for reduction of vessel accelerations. These reductions can be considered for example, for fatigue loads on crane vessels and within the loading computer of container vessels. For container vessel owners in particular, the installation of such a system has a significant return on investment, as due to reduced accelerations they can stow heavier containers higher in the ship and increase the overall intake.

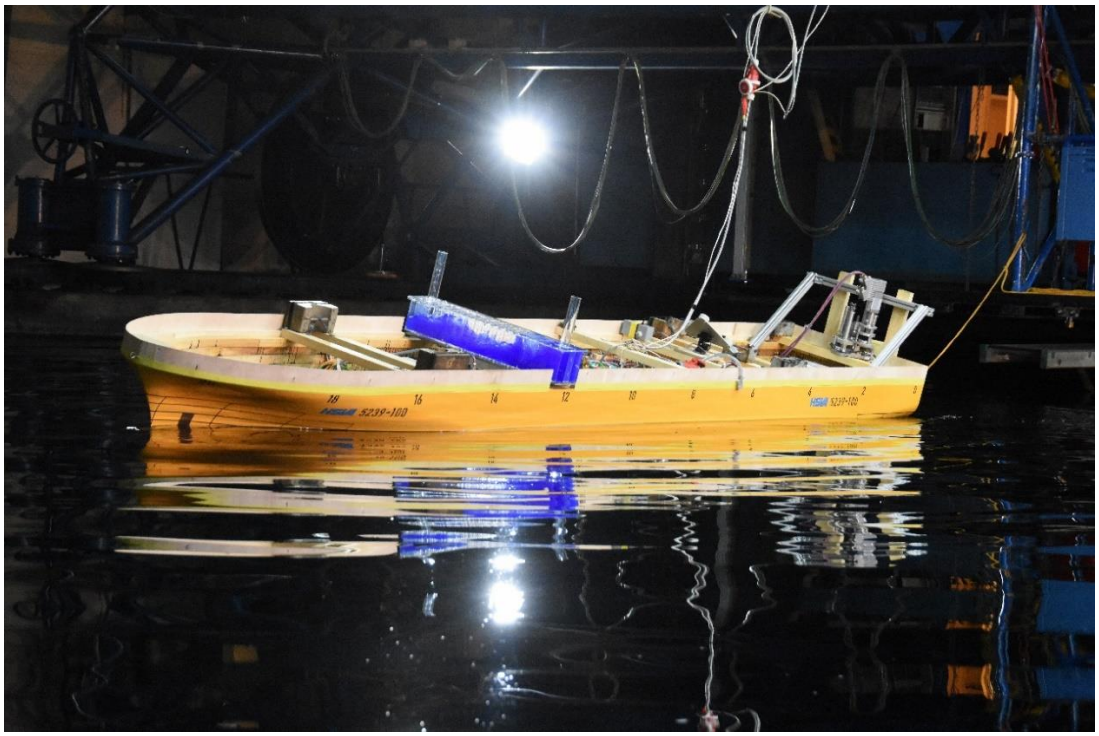

Figure 4: HSVA HERM model test of a 9,000-TEU container vessel equipped with a Hoppe FLUME tank design

There are currently 52 container ships equipped with such a system in operation or under construction. Thus, using such modern technologies opens new doors for the shipping industry to implement reliable roll-damping systems. Having a proper roll damping tank design operating correctly in all conditions can mean that bilge keels become obsolete resulting in additional fuel savings. Such applications and the related engineering services contribute to make the shipping industry more efficient, safer and reduce the carbon footprint of vessels.

Moreover, Hoppe is using the hexapod to optimize and test the developed software control for its systems. Special motion scenarios of the vessel and tank states can be simulated, in order to check if the software is reacting as expected or if certain parameters need to be changed in order to achieve optimum tank damping results.

Bastian Marquardt
Dipl.-Ing. / Naval Architect

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