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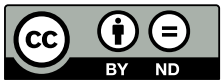

Modelling density induced ship forces during lockage

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For navigation locks, the forces on moored ships during the lockage are a most relevant design criterion, as they are a measure for the safety of the ships during the locking process. This has to be evaluated a-priori with physical or numerical models (e.g. Thorenz & Anke, 2013). For locks at the boundary between fresh and saltwater regions, the situation differs significantly from locks with a constant water density. For the new lock of Brunsbüttel at the Kiel-Canal, a major sea lock with a chamber length of 360 m and a design ship size of ~40000 t, physical mode tests were performed. The lock model was built with a scale of 1:47 and was operated with fresh water in order to test the lock performance. Later these tests were complemented by further numerical tests, which additionally included the impact of salinity. The numerical tests were performed on the basis of the software package OpenFOAM® 2.3.1 (Figure 1).

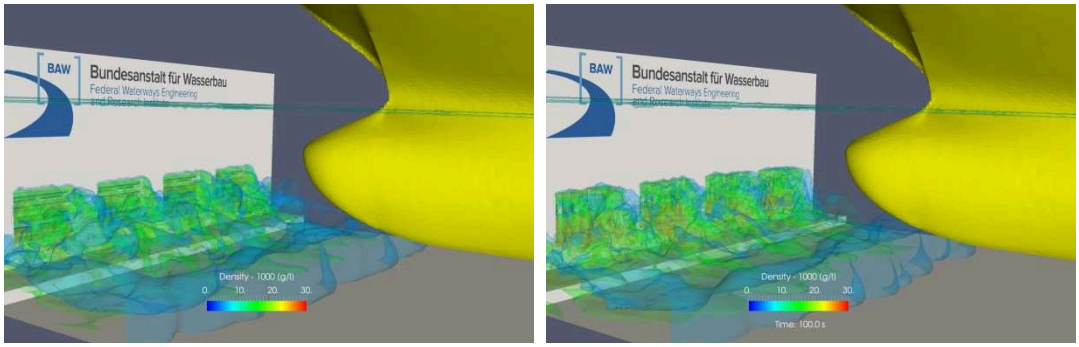

Figure 1: Salt water entering the model with horizontal breaker bars (left) and vertical breaker bars (right). The bow of the vessel is visible in yellow.

The solver "interDyMFoam" was enhanced for this task by a transport equation for salt with the diffusion coefficient coupled to the turbulence model. The density coupling was incorporated in the computation of the mixture density from the water content. Both a Boussinesq approximation and a full integration into the momentum equation were tested. The turbulence was computed on the basis of a Large Eddy Simulation (LES), using a k-equation subgrid-scale turbulence model. The large scale mixing of salt is thus directly modelled and the impact of stratification on the turbulence is directly taken into account. With this enhanced numerical model, the lock of Brunsbüttel was investigated. The model included moving valves and a moving vessel with six degrees of freedom, held in position by a set of springs which resembled the mooring line system. With this model, the impact of high salt contents and different geometries on the vessel was tested.

Literature

Thorenz, C.; Anke, J. (2013): Evaluation of ship forces for a through-the-gate filling system, Proceedings of the SMART RIVERS Conference 2013, Liege (BE), Maastricht (NL), 23-27 September 2013.