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Ship propulsors: accuracy vs. speed

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Bed and bank protection is part of the maintenance measures carried out on German inland waterways. Due to the fact that larger ships with stronger engines and propulsion systems are being developed the bed loads as well as the bed erosion will increase. Besides the wave loads and the near field velocities induced by the ship speed the propeller jet is one of the main reasons for bed or bank erosion, especially in manoeuvring situations. The uncertainties of experimental results, caused by the complex velocity field of the propeller jet and the grain size scaling effects, are difficult to determine. For this reason the Federal Waterways Engineering and Research Institute started a research project to investigate the river bed and bank erosion induced by the propeller jet applying numerical simulations. The aim of this project is to get a fully coupled CFD-DEM simulation including a moving ship, a rotating ducted propeller, realized by using a rotating object with the sliding interface method, and discrete particles to represent the bed and bank structures.

In order to simulate all the aspects induced by the combination of the ship hull, the ducted propeller, the rudder, the stream spread and the loads on the river bed and bank a complex numerical setup with a large and fine grid is needed. Furthermore, due to the complexity of the simulations a long simulation time will be required to estimate influences like the scour process on river beds and banks. One of the reasons for the long time needed is the gap between the ducted propeller and the nozzle which leads to small cells in combination with high velocities at the blade tips. The first improvement is to optimize the spatial resolution of the propeller and the nozzle. The second improvement is to modify the arrangement of the sliding interface between the rotor and stator grids to gain more space for larger cells. Finally the CFL number, different time schemes and iteration settings are investigated to receive the best fit between speed and accuracy. A Reynolds-Averaged-Navier-Stokes model with the OpenFOAM version 2.4.0 is used. The simulations are performed with three different propeller revolutions for five advance numbers. More than 400 different configurations are simulated to get a detailed overview of the uncertainties. Experimental results in open water conditions are used for the comparison.

Literature
