Validation of a GPU-Accelerated LBM Implementation of a Numerical Ice Tank Based on a Comprehensive Test Case Configuration Involving Voith Schneider Propulsion

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ABSTRACT

This contribution outlines the capabilities of an enhanced GPU-accelerated Lattice Boltzmann method (LBM) [1] for the simulation of ice-going Voith Schneider propelled (VSP) ships. Reported results cover a collaboration between an academic and an industrial partner, i.e. TUHH and Voith, within a joint research project to assess the ice-induced loads for cycloidal propellers. The goal is to establish a simulation framework which supports extensive parameter studies in a competitive computational time. Simulation objectives are an insight into the ice clearing capabilities of a hull, the ice's influence on the propulsion efficiency as well as the additional ice-induced blade loads. Investigated influences refer to the ice thickness, the ice floe geometry, the ship speed and/or the VSP's parameters.

The experimental and numerical ice tanks [2] are restricted to pre-broken ice floes and ice-breaking [3] is not considered. The simulated dynamics of the multiple rigid bodies system, i.e. the. ice floes, the hull and the VSP, are obtained from a monolithic coupling of the flow solver and a contact-dynamics Physics Engine (Open Dynamics Engine; ODE). For the coupling of the explicit LBM and the motion solver, a bidirectional and explicit coupling approach is used. Computations were performed on moderate LBM grids featuring about 20 million nodes using local grid refinement.

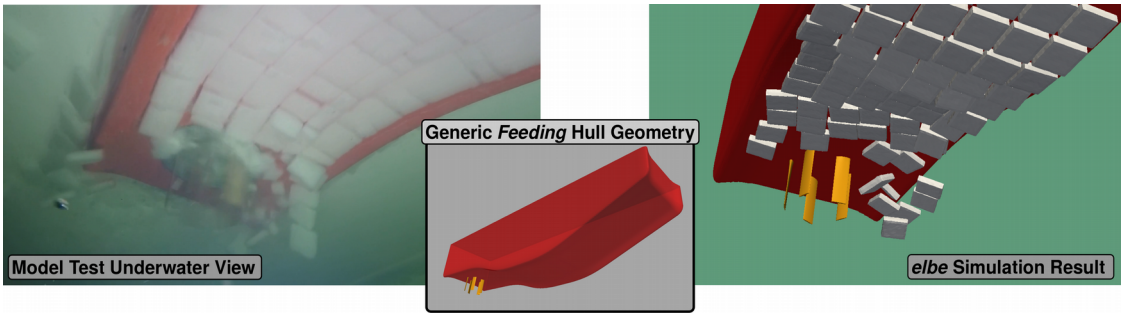

Figure 1 : Generic "Feeding" Hull Geometry in ice conditions during the model test at HSVA (left) and the simultion (right)

Prior to the assessment of ice loads, hydrodynamic validation in open-water conditions of the LBM against established FV-simulations will be reported. Subsequently, the comparison of simulated and measured ice loads experienced by a 5-bladed VSP attached to a generic hull geometry will be analyzed (cf. Fig. 1). A comparison of the ice floe dynamics displays reasonable agreement and force assessments confirm that the simulation is able to capture all important effects. Final applications are concerned with a tug geometry – propelled by 2 5-bladed VSPs – in pack ice conditions (cf. Fig. 2).

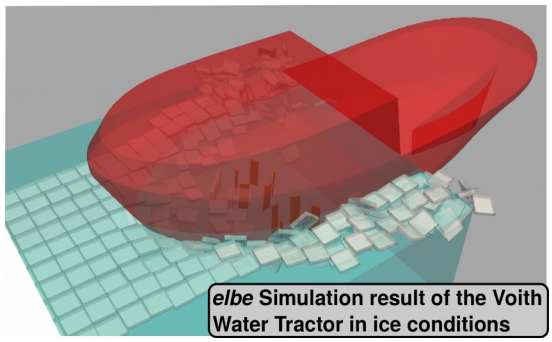

Figure 2: Simulation result of the 2 5-bladed VSP propelled Voith Water Tractor.

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