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

Martin Gehrke*, Dennis Mierke, Thomas Rung and Philipp Hauer†

*Institute for Fluid Dynamics and Ship Theory (M8)
Hamburg University of Technology (TUHH)
Am Schwarzenberg-Campus 4, 21073 Hamburg, Germany
e-mail: martin.gehrke@tuhh.de, web-page: http://www.tuhh.de/elbe

†J.M. Voith SE & Co. KG | VTA
Alexanderstraße 18, 89522 Heidenheim, Germany

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.

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).

Acknowledgement

This work has received funding from the German Ministry of Economics and Technology under grant agreement No. 03SX391G (ProEis-Project).
REFERENCES

