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Numerical improvement and validation of a naval hydrodynamics CFD solver in view of performing fast and accurate simulation of complex ship-wave interaction.

Résumé

The present thesis aims to study the efficiency and the accuracy of different numerical schemes for naval applications, especially for unsteady wave-structure (WSI) interaction problems.
A study on the interface treatment schemes is first performed. With the Volume of Fluid (VOF) interface capturing scheme, two interface convection methods and two interface conditions are tested for 2D wave propagation and 2D impact cases.
The Diagonally Implicit Runge-Kutta (DIRK) time integration schemes are then studied and applied to two types of two-phase flow solvers. The DIRK scheme is implemented within an incompressible averaged two-phase flow solver (*foamStar*) and a two-phase flow solver based on the Spectral Wave Explicit Navier-Stokes Equations (*foamStarSWENSE*).
The validity and the order of convergence of the higher-order DIRK methods are confirmed using a 2D Taylor Green Vortex flow test case. The efficiency of the DIRK method is then studied on two-phase regular wave propagation in periodic domain.
With two solvers and various DIRK schemes, two types of applications are finally studied. First, qualification analysis of regular and irregular waves in a numerical wave tank (NWT) is performed. The efficiency of each DIRK scheme is compared with various computational resolutions, and computational parameters for qualified wave propagation are proposed. Second, the seakeeping analysis of the Wigley III hull and KCS ships with a forward speed is performed. The results obtained from both *foamStar* and *foamStarSWENSE* solvers are compared with the experiment and other numerical results. The efficiency and the accuracy of the DIRK scheme with the two solvers are compared on the Wigley III hull test case.

Mots-clés : High-order scheme; Diagonally Implicit Runge-Kutta (DIRK) scheme;
OpenFOAM; SWENSE; Wave-structure interaction (WSI); Wave generation; Added resistance