Efficient FSI codes coupling with possible large added mass effects: applications to rigid and elongated flexible bodies in the maritime field.

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ABSTRACT

Fluid Structure Interaction (FSI) problems are commonly encountered in naval architecture. Even if this can be done through a monolithic approach within a single solver, a partitioned approach is most commonly used through codes coupling, especially well fitted to the resolution of complex FSI problems. Indeed, with this technique, complex models for both the fluid and the structure can be used because each solver can be numerically adapted and dedicated to its own physics.

In this work, two different general solvers are used: ISIS-CFD and MBDyn, for the fluid and the structural part, respectively. ISIS-CFD is a RANSE solver developed by the DSPM team of LHEEA. It is available as a part of the FINE/Marine computing suite and dedicated to marine applications ([1]). MBDyn is an open-source solver intended to solve multi-disciplinary problems including non-linear dynamics of rigid and flexible bodies subjected to kinematic constraints, along with active controls ([2]). The combination of these two solvers makes possible the study of a broad spectrum of applications in the marine field which cannot be solved with a unique solver.

To reach an efficient and robust algorithm, the coupling iteration occurs during the non-linear iterations of the fluid solver because it is the most costly part in our applications. To tackle the destabilising added-mass effects, a relaxation technique of the structural kinematics is used. The latter can be viewed as a modification of the artificial added mass method and does not need any intrusive modification of the structure solver. The relaxation operator is naturally related to the artificial added mass operator. Efficiency of the coupling is optimal when the artificial added mass is close to the physical one. The computation of the approximate or exact added mass operator for rigid and beam-like bodies is carried out through an on-line resolution of an original pressure-like equation integrated in the fluid solver ([3]). Compared to a non-FSI simulation (unsteady simulation with imposed motion), the number of non-linear iterations to converge the fluid part is similar, even when large added mass effects occur. The additional cost of the FSI cases is then reduced to the resolution of the structural part and to the mesh deformation technique.

The computation chain consisting of ISIS-CFD and MBDyn has been validated numerically for rigid bodies with six degrees of freedom and strong added mass effects ([4]). Test-cases were carried out for a ship in regular head waves or with active control of appendages (roll damping), where good agreement with the experimental data was obtained. Applications involving complex mechanical systems and flexible hull will be presented to demonstrate the capabilities of such a coupling.

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