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Strong coupling scheme for thin-shell structure and fluid with implicit particle-in-cell method

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An implicit particle-in-cell method using a fixed Eulerian mesh and a set of Lagrangian particles is proposed to simulate fluid-structure interaction (FSI) problems with hard thin-shell structure such as vehicular structures. The authors have been developing a full Eulerian scheme for solid dynamics[1]. A full Eulerian method, however, cannot compute thin-shell structure with high accuracy because it introduces the numerical dissipation of material interfaces and history-dependent variables of structures due to the advection. To retain the sharp interface, K. Sugiyama et al.[2] proposed the particle-in-cell method for FSI simulations of flexible neo-Hookean tube flows.

In this study, we propose a novel implicit particle-in-cell formulation using a fixed Cartesian mesh to simulate FSI problems with hard thin-shell structure such as vehicular structures. In the present method, the unified equation of motion for fluid and structure is computed on the fixed Cartesian mesh. To avoid numerical dissipation of material interfaces and history-dependent variables of solid, Lagrangian particles represent the solid region and carry history-dependent variables such as solid deformation tensor. To verify the present approach, several numerical examples of FSI problem with hard solid will be demonstrated in the presentation.

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