A numerical investigation of the added mass effect due to fluid-structure coupling in a rectangular tank.

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ABSTRACT

The objective of this paper is to present a numerical model for fluid-structure interactions (abbr. FSI). Indeed, emergence of hybrid vehicles, system such as Start & Stop and reduction of engine noises have contributed to the appearance of components previously inaudible. It is therefore necessary for fuel tank manufacturer to improve the vibro-acoustic of their product. Numerical simulation of the fluid-structure interaction is a way to identify the noise generated by fuel sloshing and to reduce costly experimental tests.

Its purpose, within the context of sloshing effect in a movable partially-filled tank, is to improve understanding of interactions between fluid and the dynamics of the tank flexibly attached to the vehicles. The FSI investigation is based on an added mass corrected version of the classical strongly-coupled partitioned scheme exposed in [1]. Concerning the structure model, the tank is governed by the Fundamental Principle of Dynamics (FPD). The potential fluid flow theory used to solve the fluid problem is completed by a free surface problem condensation in order to reduce the problem size to solve.

A particular case of a closed and full tank is treated and underlines the fact that the added mass effect depends on mass ratio (m_r) between the fluid and the tank. In this case, the added mass term is exactly equal to the mass of the fluid. A numerical validation using a simple finite element approach and a sensibility study with time accuracy order allow determining critical mass ratio for convergence.

Concerning the general case for a partially-filled tank, the added mass effect depends of the aspect ratio of the fluid domain (H/L). The calculation of the added mass term is based on [2] the assumption that the fluid flow is inviscid and that the convective effects can be neglected with regard to the pressure gradient field. FSI calculations based on the non-corrected coupling-scheme have been conducted and show the convergence limit.

For both cases the added mass term is integrated to the corrected staggered scheme and results show that the corrected version permits to systematically converge to the coupled solution. For rare cases where added mass effect are not so penalizing, it however permits to significantly reduce the iterations required. Finally, it is shown that the added mass effect is not directly relied upon the water height but rather points out its direct dependency with the aspect ratio of the fluid domain, column shape tank being the best candidates for the higher added mass effect.

REFERENCES

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