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Incorporating effective transmission conditions between fluid and solid domains in transient wave propagation problems using the mortar element method

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In leading edge industrial applications, assessing structure integrity is an important aspect of safety requirements, and is often performed using Ultrasonic Testing (UT) methods. They rely on the interaction between high-frequency mechanical waves and potential flaws or material inhomogeneities. Insuring the reliability of a UT method is a challenging task and may require modeling and simulation. In the present communication, we consider the problem of efficient numerical modeling of high-frequency transient waves propagation in a configuration where a solid material is surrounded by a fluid, and at the fluid – solid interface a thin layer of material is present. This configuration typically occur when representing UT of immersed coated specimens. This type of configuration entails at least two difficulties : (1) The wave velocity being significantly lower in the fluid, one needs to resort to non-conforming meshes between the fluid and solid domain in order to recover sufficient performances; (2) The presence of the thin coating interface necessarily discard any attempt to meshing this interface, since this approach would lead to a restrictive stability condition on the time scheme. The traditional approach is to rely on Effective Transmission Conditions (ETC) [1], the resulting question being to propose a mean of incorporating such conditions in the complete numerical scheme. To address both difficulties, we rely on the mortar element method [2]. By doing so, we are able to incorporate both mesh non-conformities and the ETC in the fully discrete numerical scheme. We are able to prove that the stability condition is optimal, in the sense that it is the lowest stability condition obtained from the fluid and solid propagator taken independently. We provide 2D and 3D numerical results to illustrate our approach.

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