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Bulk/Hull Cavitation Induced by Underwater Explosion: Effect of Material Elasticity and Surface Curvature

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Abstract : Bulk/hull cavitation evolution induced by an underwater explosion (UNDEX) near a free surface (bulk) or a deformable structure (hull) is numerically investigated using a multiphase compressible fluid solver coupled with a one-fluid cavitation model. A series of two-dimensional computations is conducted with varying material elasticity and surface curvature. Results suggest that material elasticity and surface curvature influence the peak pressures generated from UNDEX shock and cavitation collapse, as well as the bulk/hull cavitation regions near the surface. Results also show that such effects can be different for bulk cavitation generated from UNDEX-free surface interaction and for hull cavitation generated from UNDEX-structure interaction. More importantly, results demonstrate that shock wave focusing caused by a concave solid surface can lead to a larger cavitation region and thus intensify the cavitation reload. The findings can be linked to the strength and the direction of reflected waves from the structural surface and reflected waves from the expanding bubble surface, which are functions of material elasticity and surface curvature. Shockwave focusing effects are also observed for axisymmetric simulations, but the strength of the pressure contours for the axisymmetric simulations is less than those for the 2D simulations due to the difference between the initial shock energy. The current method is limited to two-dimensional or axisymmetric applications. Moreover, the thermal effects are neglected and the liquid is not allowed to sustain tension in the cavitation model.

Keywords : cavitation, UNDEX, fluid-structure interaction, multiphase
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