UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF ENGINEERING, SCIENCE & MATHEMATICS

SCHOOL OF ENGINEERING SCIENCES

Doctor of Philosophy

FREE-LAGRANGE SIMULATIONS OF SINGLE CAVITATION BUBBLE COLLAPSE

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A Free-Lagrange method has been applied to simulate the collapse of single cavitation bubbles near various boundary types. The simulations resemble an underwater explosion or laser- or spark-generated bubble, where the bubble evolution is driven by a high initial pressure difference between the bubble content and the surrounding water. The significant advantages of this method in simulating highly deforming fluid problems are minimal numerical diffusion and that the material interfaces are sharply resolved because the computational mesh moves with the same velocity as the local flow. In addition, the Free-Lagrange approach avoids the classical problem of mesh tangling and distortion faced by conventional Lagrangian schemes as the connectivity of the computational mesh is allowed to evolve naturally.

As the collapse of single cavitation bubble near a boundary is typically axisymmetric, a swirl-free axisymmetric Free-Lagrange code was developed. Simulations of conical shock waves for various geometries and axisymmetric shock propagation in a material incorporating strength were carried out for validation purposes.

Here, the code, which employs second order space and first order time accurate Godunov-type solvers, has been used to simulate the expansion and collapse of single cavitation bubbles near a planar rigid boundary, an aluminium layer and a free-surface for various collapse parameters. The results clearly capture the phenomena of bubble collapse that are believed to be responsible for cavitation erosion, i.e. high-speed liquid jet impact and shock/blast wave emission. It is concluded that numerical simulations using the Free-Lagrange method are well suited to the study of highly deforming fluid problems, particularly in the study of the growth and collapse of single cavitation bubbles.