COUPLED FLUID-STRUCTURE TECHNIQUE FOR UNDERSEA APPLICATIONS

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Accurate prediction of underwater explosion damage against surface ships and submarines is an important aspect of naval weapon design. The stiffness of water makes this a difficult problem; target deformation modifies the pressure in the surrounding fluid, changing the explosive loading. Thus, it is necessary to couple the fluid/explosive modeling with the structure simulation.

The coupling methodology combines an Euler MUSCL style fluid solver [1] with the Navy DYNA_N finite element structure solver [2], which is incorporated in the GEMINI code [3]. Each code runs as a separate process with information shared at the end of each fluid solver step. The format of this exchanged data conforms to the standard coupler interface [3]. The fluid solution is carried out on a fixed, Cartesian product grid, which does not coincide with the body surface. Determining cells that are in the fluid, in the structure and intersected by the structure surface is performed by geometry routines included in the Euler module.

This paper discusses the treatment of the body boundary conditions within the Euler solution and demonstrates the efficacy of this treatment on laboratory scale experiments. The modified stair-step approach is used to treat the body boundary; partial Euler cells are not allowed and an Euler cell is completely inside or outside the fluid. However, to obtain sufficient accuracy, the orientation and velocity of the body surface is accounted for by adjusting the fluxes through the blocked cell edges. This approach has the advantage of allowing thin, double-wetted surfaces to be easily treated without introducing complicated data structures. Such surfaces are common in underwater applications where the vessel or submarine may have thin double hulls.

Computational examples are presented for laboratory scale tests of a planar shock interacting with a cylinder and an explosion within a water-filled cylinder. Full-scale cases are presented for the explosive loading of a double-walled cylinder, an externally stiffened cylinder and a ship. The first two cases are two-dimensional and demonstrate the viability of the method, while the latter are three-dimensional and provide proof of principle for the application of this method to complex naval structures.

References

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[3] Wardlaw, A. B., Jr., "Gemini Theory Manual", NSWCIH TR 2500, in preparation.