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A comprehensive subgrid air entrainment model for Reynolds-averaged simulations of free-surface bubbly flows JINGSEN MA, ASSAD A. OBERAI, DONALD A. DREW, RICHARD T. LAHEY, JR, Rensselaer Polytechnic Institute, MARK C. HYMAN, Naval Surface Warfare Center–Panama City — The simulation of free surface bubbly flows using a two-fluid model remains challenging in part due to the lack of a comprehensive air entrainment model that can predict the location and rate of air entrainment for a wide range of flows. In this study we derive one such model and implement it into a computational multiphase fluid dynamics (CMFD) framework that solves the Reynolds-averaged two-fluid equations. The subgrid air entrainment model is derived from a simple argument that the wave action near the air/water interface causes it to ingest air bubbles and they are entrained into the liquid if their downward velocity exceeds that of the interface. This yields a simple expression for the rate of entrainment as a product of the downward gradient of the liquid velocity near the free surface and the turbulent kinetic energy. We have tested the performance of this model and CMFD in simulating the bubbly flow due to a plunging liquid jet, in a hydraulic jump and around a full-scale naval surface ship by comparing with experimental data. It's found that in each case the subgrid air entrainment model and the two-fluid modeling approach yields accurate results.

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