An Improved Multiphase SPH Model for the Simulation of Water Entries

Zifei Meng[1], Pingping Wang[1], Furen Ming[1], Pengnan Sun[2], Han Cheng[1], and †*A-Man Zhang[1],

[1]College of Shipbuilding Engineering, Harbin Engineering University, Harbin, Heilongjiang, China
[2]Ecole Centrale Nantes, LHEEA res. dept. (ECN and CNRS), Nantes, France

*Presenting author: zhangaman@hrbeu.edu.cn
†Corresponding author: zhangaman@hrbeu.edu.cn

Abstract

As a complex fluid-structure interaction problem, water entry plays a critical role in ocean engineering and many other fields. In some cases when the deadrise angle of the structure is very small or the initial velocity of the entry is large, the effect of the air phase and its compressibility on the impacting load should be taken into account. Significant progress on this issue have been made by many other researchers. However, many difficult problems have not been well solved so far because of the nonlinearity and complexity of the air phase in some water-entry problems. Considering the large deformation, fragmentation and splashing of the free-surface as well as the air phase effect in the process of water entries of large Froude numbers, in this paper, we develop an improved multiphase SPH model using Roe approximate Riemann solver. This model is applicable for complex interfacial flows even with high density ratios and large Reynolds numbers. To reduce the computational cost, a novel nonreflecting boundary is arranged around the water domain to minimize the computational domain and avoid the reflection of pressure waves. Besides, an improved particle shifting technology is adopted and it is able to shift the particles at the multiphase interface and the adjacent area in all directions, and thus achieve a more uniform particle distribution which improves the SPH accuracy. Several numerical tests show that the improved multiphase SPH model is robust and accurate for the simulation of a variety of water entries considering air-phase effects.

Keywords: Water-entry problem; Multiphase SPH; Nonreflecting boundary condition; Improve particle shifting technology

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