15th World Congress on Computational Mechanics (WCCM-XV)
8th Asian Pacific Congress on Computational Mechanics (APCOM-VIII)
31 July – 5 August 2022, Yokohama, Japan

A Time Consistent Method by Preconditioning of the Diffusion Term for Unsteady Gas-Liquid Two-Phase Flows

Tianmu Zhao[1*] and Byeong Rog Shin[2]

[1] University of Miyazaki, Miyazaki 889-2192, z370701@student.miyazaki-u.ac.jp
[2] University of Miyazaki, Miyazaki 889-2192, brshin@cc.miyazaki-u.ac.jp

Key Words: *Gas-Liquid Two-Phase Flow, Time Consistent Preconditioning, Roe Upwind Scheme, Riemann Problem*

Gas-liquid multiphase flow often happens in hydro machines. In cavitating flow as an example of typical gas-liquid two-phase flow, when its bubble occurs and collapses near body surfaces, it causes the noise, vibration, and damage to the hydro devices. In the sense of reducing these unfavorable effects, in order to clarify and understand the behavior of cavitating flow, several efforts to propose cavitating flow model and numerical method have been made [1,2]. However, due to its strong and complicated unsteady flow phenomenon such as phase changes and the co-existence of compressible and incompressible flow nature, the mathematical model and numerical method is not established yet. Recently, Shin et al. [3] has proposed a preconditioned dual time-stepping method based on a homogenous cavitation model to treat cavitation problems. This method has solved many gas-liquid two phase flow problems associated with wide range of speeds of sound, but relatively it takes time to get the unsteady solution.

In this study, a time consistent preconditioning method for gas-liquid multiphase flows is proposed. A finite-difference 4th-order Runge-Kutta method and a Roe-type flux splitting method with the 3th-order MUSCL TVD scheme are employed. The artificial viscous terms in the flux splitting are modified by using the preconditioning matrix to enhance the numerical stability and accuracy of unsteady computation for compressible and incompressible flow with arbitrary Mach numbers. By using the concept of the homogeneous equilibrium model, gas-liquid two-phase flow is modeled to a pseudo single-phase flow, taking into account the compressibility of the mixed medium. From the above, the present method permits simple treatment of the whole gas-liquid two-phase flow including wave propagation, large density changes, and compressible and incompressible flow characteristics.

As numerical examples, Riemann problems of gas-liquid two-phase shock tube problem were applied to investigate the validity of the present method. From the computation, it showed a good prediction of pressure, density, velocity and void fraction distributions in comparison with Roe’s approximate solutions, and quite well simulates unsteady phenomena of the shock wave including the propagation of both compression and expansion waves. The reliability and applicability of the present method to arbitrary Mach number flow problems were confirmed as consequence. Detailed observations of shock and expansion wave behaviors in the gas-liquid media and comparisons of predicted results with exact solutions are provided and discussed.

REFERENCES

[1] Deshpande, M., Feng, J. and Merkle, C.L. *ASME J. Fluids Engng.* (1997) **119**: 420-427.

[2] Shin, B.R., Iwata, Y. and Ikohagi, T. *Computational Mechanics* (2003) **30**: 388-395.

[3] Shin, B.R., Yamamoto, S. and Yuan, X. *ASME J. Fluids Engng.* (2004) **126**: 605-612.