Investigation of Enhanced Polygon Wall Boundary Model in PNU-MPS Method

Soh-Myung Chung*, Seong-Jun, Ji*, Jong-Chun, Park*

Se-Min, Jeong†, and Kyung-Sung, Kim††

* Department of Naval Architecture and Ocean Engineering
Pusan National University
2 Busandaehak-ro 63beon-gil, Geumjeong-gu, Busan 46241, Korea
e-mail: jcpark@pnu.edu, web page: http://sil.pusan.ac.kr

† Department of Naval Architecture and Ocean Engineering
Chosun University
309 Pilmon-daero, Dong-gu, Gwangju 61452, Korea
e-mail: smjeong@chosun.ac.kr

†† School of Naval Architecture and Ocean Engineering
Tongmyong University
428 Sinseon-ro, Nam-gu, Busan 48520, Korea
e-mail: keiuskim@tu.ac.kr

ABSTRACT

With regard to demonstration of fluid flow, there are two descriptions which are Eulerian description and Lagrangian description. In the field of CFD (Computational Fluid Dynamics), a number of studies relevant to grid method based on Eulerian description have been conducted generally. However, when the grid method is employed to simulate flow field, it is inevitable to give consideration to convection term which generates severe numerical diffusion and fluctuation. To obtain the accuracy of solution, a different type of method based on Lagrangian description is come to the fore. Numerical approaches following Lagrangian description have been called meshfree or particle method. Even though particle method does not accompany convection term and fully satisfies conservation of mass, its studies have not been carried out extensively because it is difficult to implement the boundary conditions correctly due to insufficient number of particles in the vicinity of boundary. It affects directly the stability of flow field and accuracy in computation.

In MPS (Moving Particle Semi-implicit) method [1], fixed-type of dummy particles are placed inside wall boundary. By placing extra particles as the wall, it seems to be not easy to satisfy the boundary condition for sharp-edged or extremely thin body configuration.

In this study, the enhanced polygon wall boundary model, which was suggested originally by Mitsume et al. [2], is employed to the PNU-MPS (Pusan-National-University-modified MPS) method [3] to improve and stabilize the analysis of fluid flow with arbitrary-shaped body including sharp-edged body configuration without any additional particles. The developed simulation method, called as PNU-MPS-POLY, is adopted to the Couette flow and the lid-driven cavity flow with various corner angles. The present simulation results are validated through comparison with the analytic solutions, the experiments [4], and other simulation results [5,6].

REFERENCES

[1] Koshizuka, S, and Oka, Y, "Moving-Particle Semi-Implicit Method for Fragmentation of Incompressible Fluid", *Journal of Nuclear Science and Engineering*, **123**, 421-434 (1996).

[2] Mitsume, N., Yoshimura, S., Murotani, K. and Yamada, T., "Explicitly represented polygon wall boundary model for the explicit MPS method", *Computational Partcile Mechanics*, **2**, 73-89

(2015).
[3] Lee, BH, Park, JC, Kim, MH, and Hwang, SC, "Step-by-step improvement of MPS method in simulating violent free-surface motions and impact-loads", *Computer Methods in Applied Mechanics and Engineering*, **200**, 1113-1125 (2011).
[4] Ghia, U., Ghia, K.N., and Shin, C.T., "High-Re Solutions for Incompressible Flow Using the Navier-Stokes Equations and a Multigrid Method", *Journal of Computational Physics*, **48**, 387-411 (1982).
[5] Demirdzic, I., Lilek, Z. and Peric, M., "Fluid Flow and Heat Transfer Test Problems for Non-Orthogonal Grids: Bench-Mark Solution", *International Journal for Numerical Methods in Fluids*, **15**, 329-354 (1992).
[6] Moon, JK, Park, JC, Chun, HH, and Suh, SB, "Numerical Simulation on Laminar Flow Past a Rotary Oscillating Circular Cylinder", *Journal of the Society of Naval Architects of Korea*, **42(4)**, 368-378 (2005).